Vol. 15 No. 9 September 1961 Published Monthly

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INSTRUMENT PRACTICE

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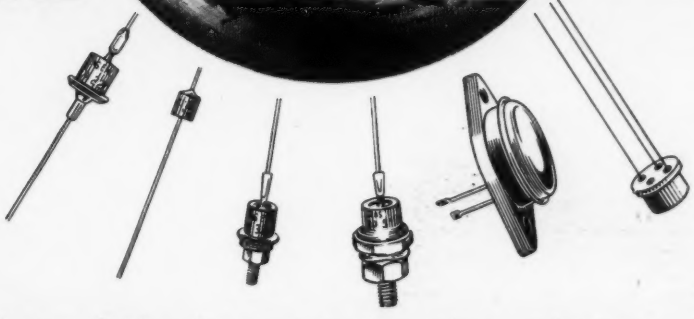

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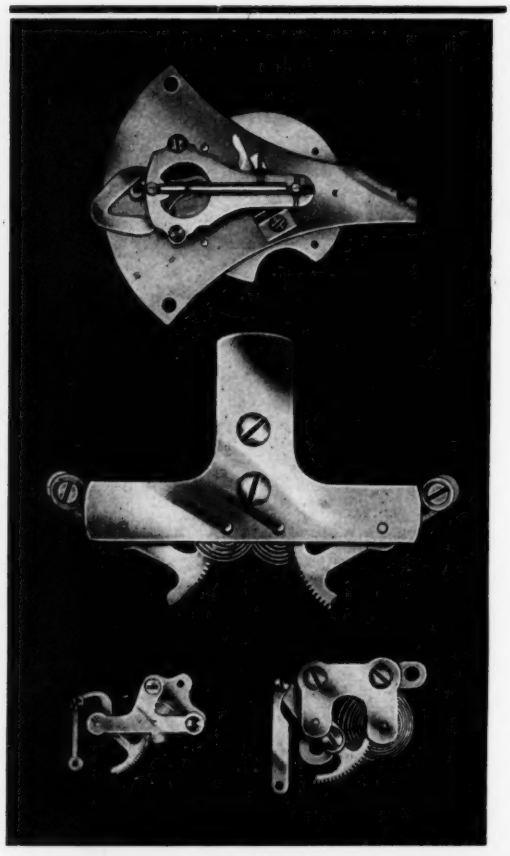

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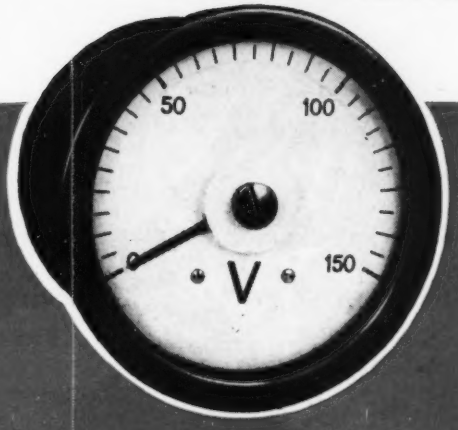

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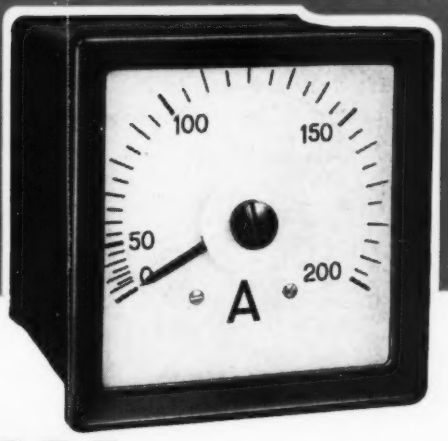
240° switchboard instruments



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reliability and stability—ensured by permanence of magnetic flux and high torque/weight ratio.

accuracy—All instruments are individually calibrated. Accuracy is well within the limits specified in B.S.89:1954.

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easy-to-read dials—Clearly marked scales and specially shaped pointers facilitate routine reading at a distance and precise reading at close range.

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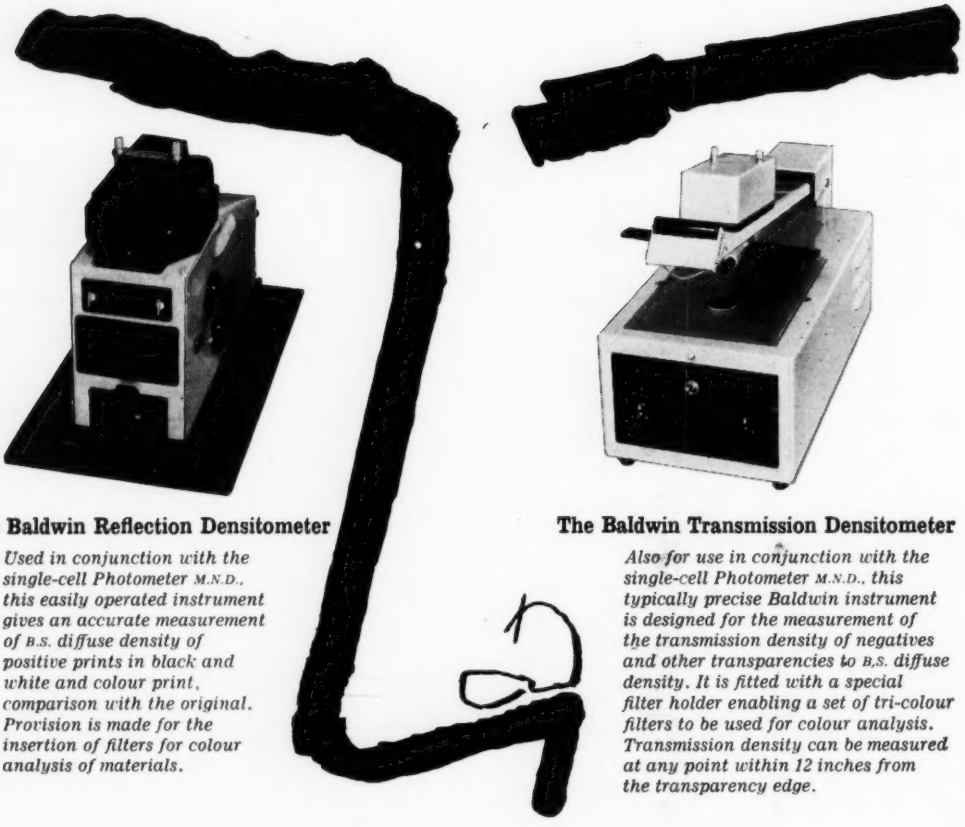

The Baldwin Reflection Densitometer

Used in conjunction with the single-cell Photometer M.N.D., this easily operated instrument gives an accurate measurement of B.S. diffuse density of positive prints in black and white and colour print, comparison with the original. Provision is made for the insertion of filters for colour analysis of materials.

The Baldwin Transmission Densitometer

Also for use in conjunction with the single-cell Photometer M.N.D., this typically precise Baldwin instrument is designed for the measurement of the transmission density of negatives and other transparencies to B.S. diffuse density. It is fitted with a special filter holder enabling a set of tri-colour filters to be used for colour analysis. Transmission density can be measured at any point within 12 inches from the transparency edge.

The infallible eyes

As the techniques of commercial photography become more and more complex, the comparison between prints or negatives cannot rest on the judgment of the human eye, however well experienced. Today, the unvarying accuracy of Baldwin instrumentation is needed.

Instrument Division

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* No. 1 of a series to acquaint Engineers of the very practical advantages of PILOT Plug Gauges which *reduce* gauging costs.

WIRE TYPE GAUGES. (.001" to .510" diameter)

The gauging member is held in a split brass bush so that when wear takes place it may be—

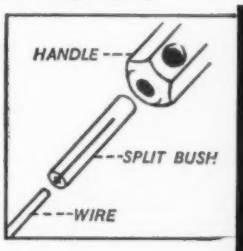
(a) Reversed in the handle enabling the unworn end to be used.

(b) The worn portion ground off and the unworn portion advanced out of the handle.

The gauging member can thus be fed out like a lead pencil.

Gauges whose gauging member is a solid extension of the steel handle have only ONE life.

The replaceable and reversible PILOT gauging member is 2" long thus ENORMOUSLY REDUCING gauging costs.



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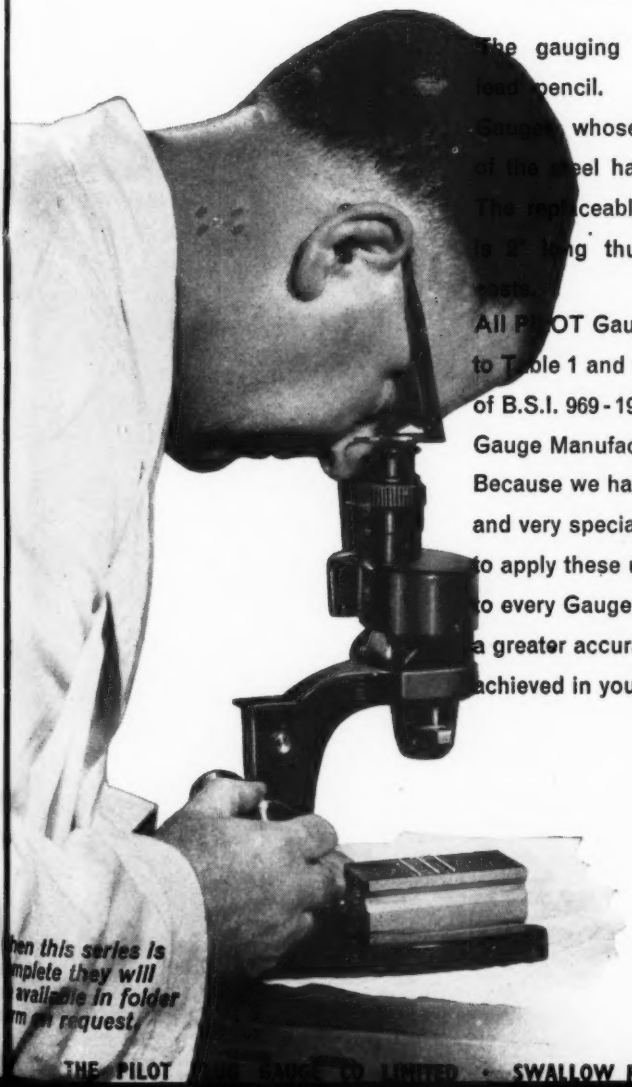

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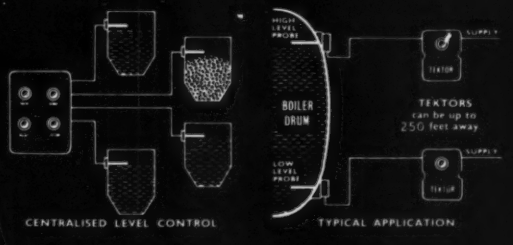

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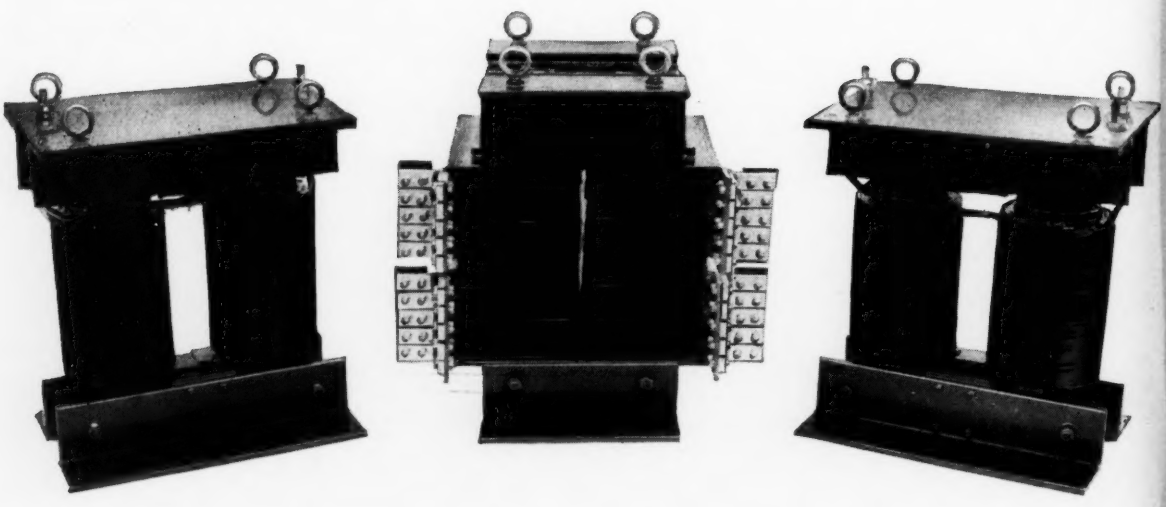

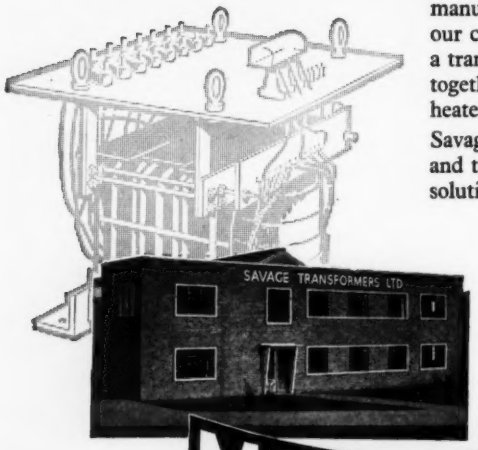

The three Massicore instruments illustrated were designed and manufactured by Savage to meet the special requirements of one of our customers. The partnership consists of two reactors forming a transductor to control a single-phase 40 KVA heating load, together with a step down transformer for low voltage heater elements.

Savage manufacture many different types of transductors and transformers and are always pleased to help with the solution of any new problem.

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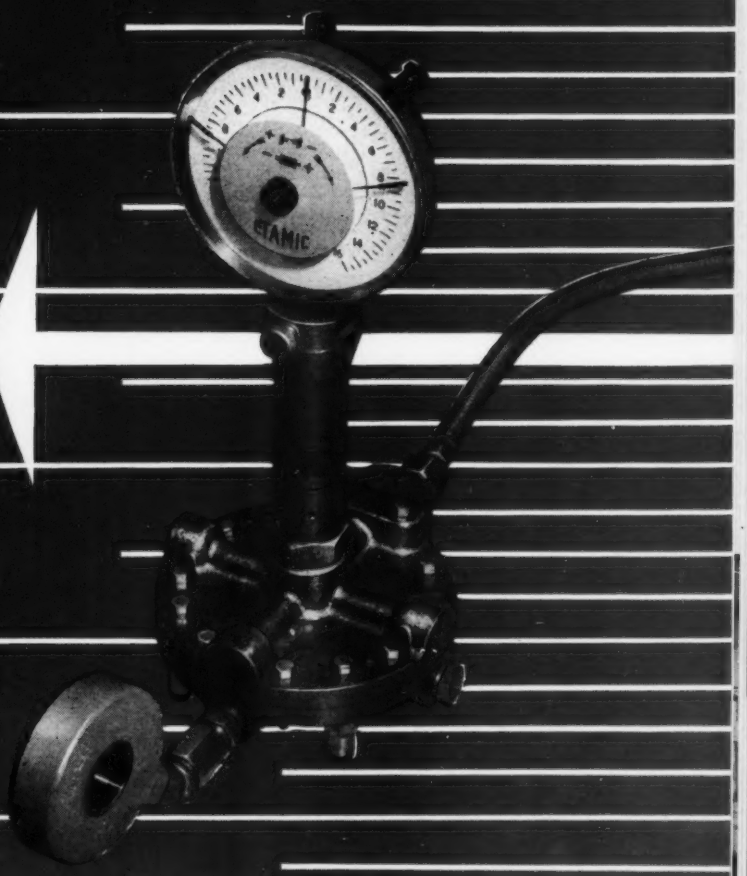
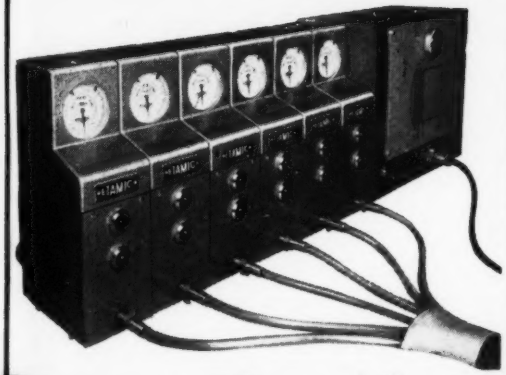
AIR GAUGING EQUIPMENT





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Direct gauge readings or observation of pre-set tolerance zone to expedite quantity gauging of external or internal diameters.

UNEXCELLED ACCURACY
Over wide measuring ranges OMT—ETAMIC air comparators have a gauging accuracy from 0.00005" to 0.00000625".

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Complete multi-gauging systems with or without automatic feeding, acceptance and rejection mechanisms devised to customer requirement. Illustration on the left shows a compact gauging assembly for simultaneous checking of six piston diameters.

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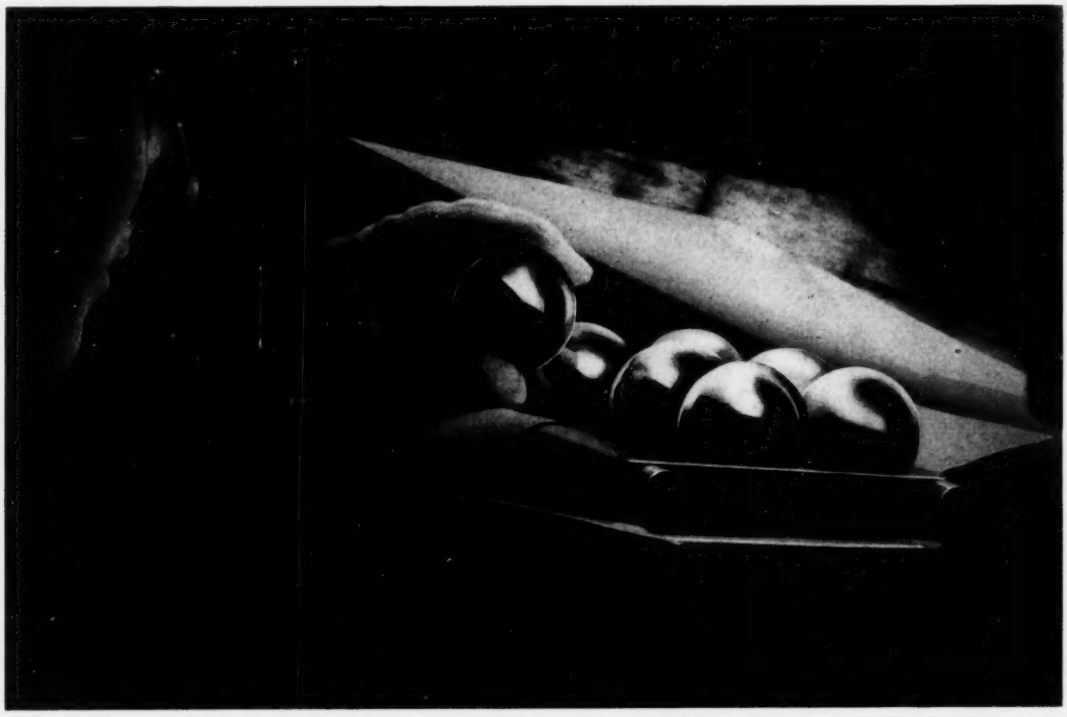
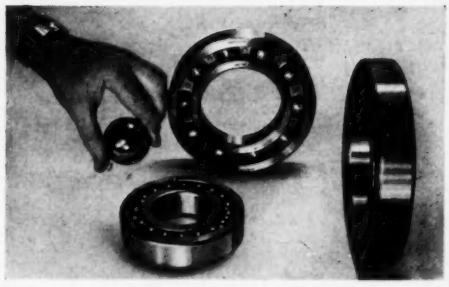


EYE ON THE BALLS



A striking picture no doubt—but only one out of a hundred that would tell a story of a stage in the manufacture of Hoffmann Bearings.

At this point in the story, it tells how human eyes are employed for the inspection of Hoffmann Steel Balls—the balls which later become the rolling elements of Hoffmann Ball Bearings. These eyes, extremely keen, highly trained, perceive the almost imperceptible, detecting cracks and blemishes of microscopic dimensions on the highly polished surfaces of the Steel Balls.

Hoffmann Bearings—masterly engineered—superbly finished are brought meticulously through every stage of production to make the final product which stands unsurpassed for high degree of accuracy and quality: behind every Hoffmann Bearing lies over 60 years experience.

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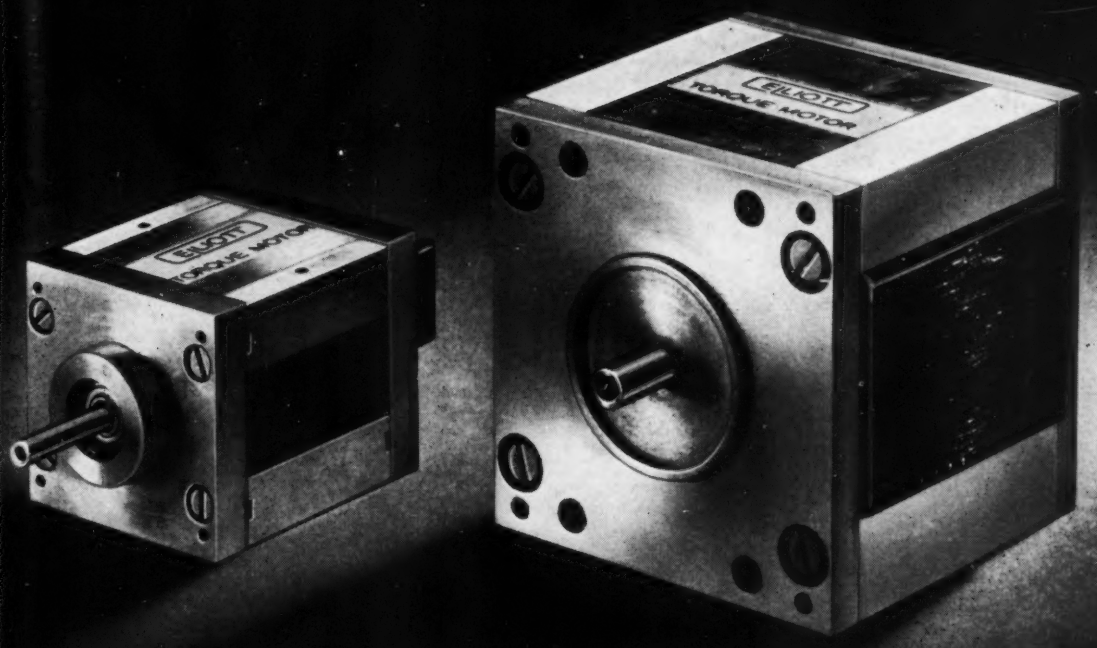
Torquemotors



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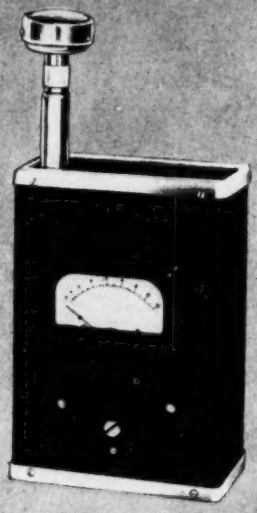

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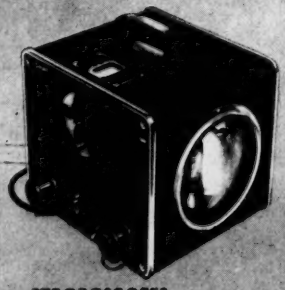

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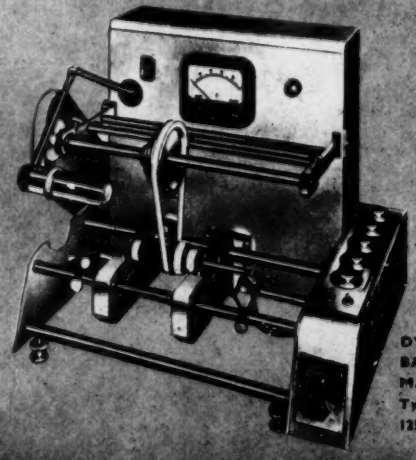

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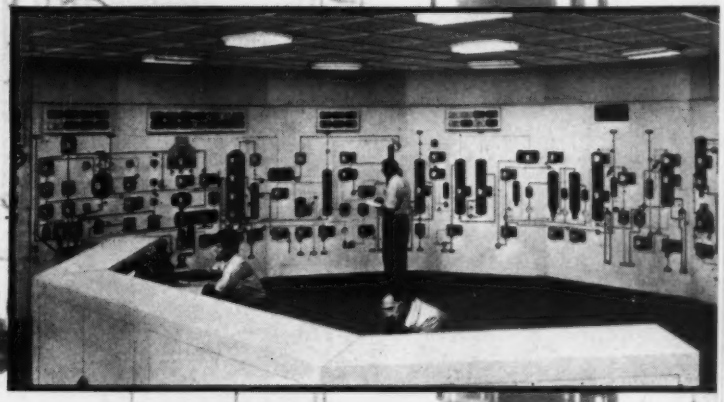

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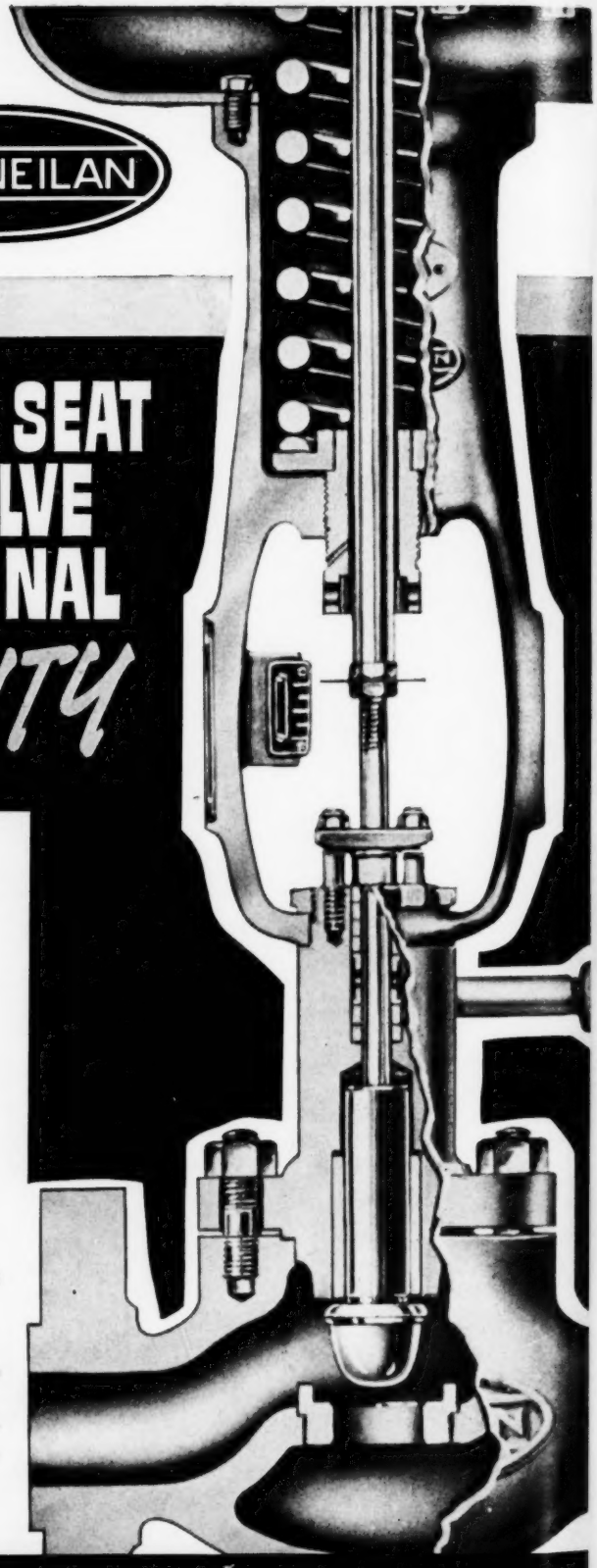

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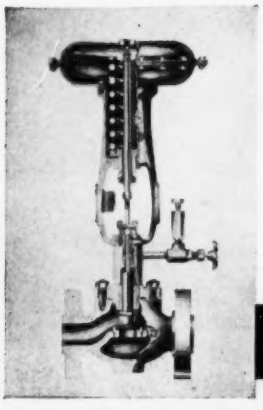

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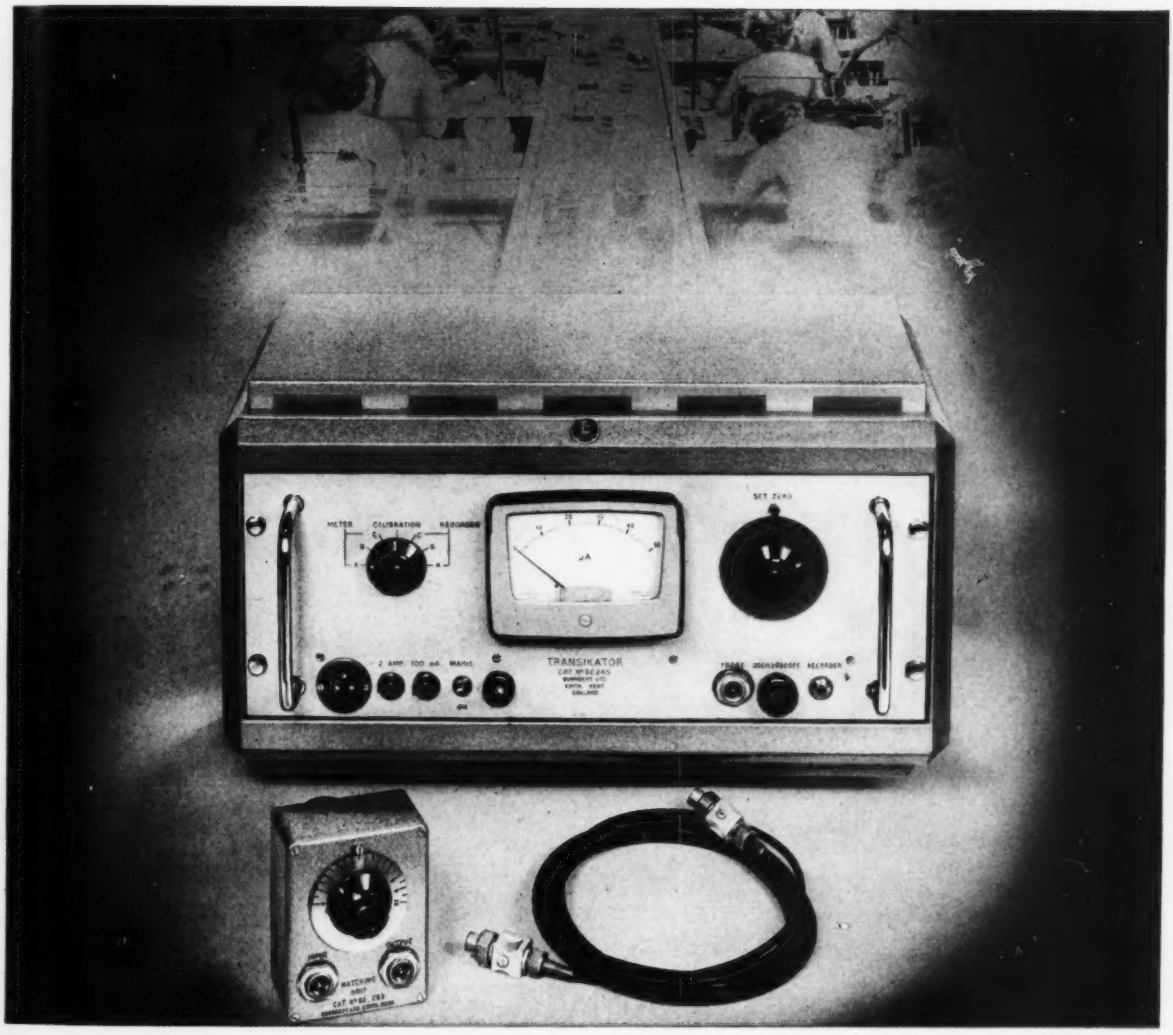

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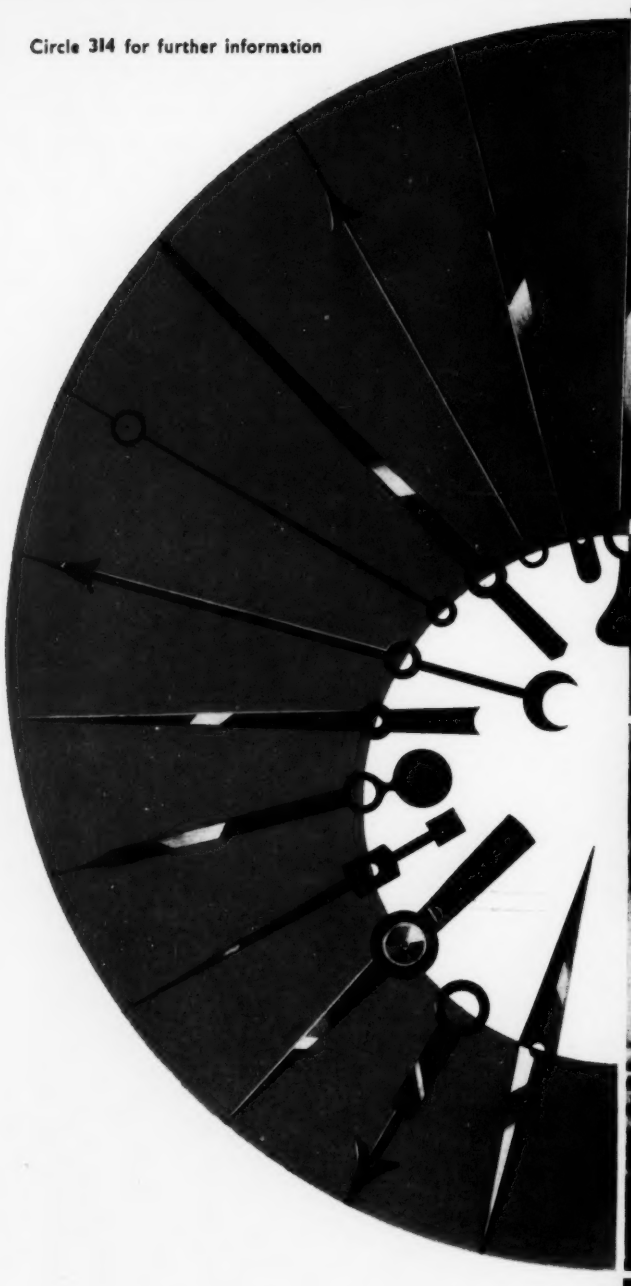

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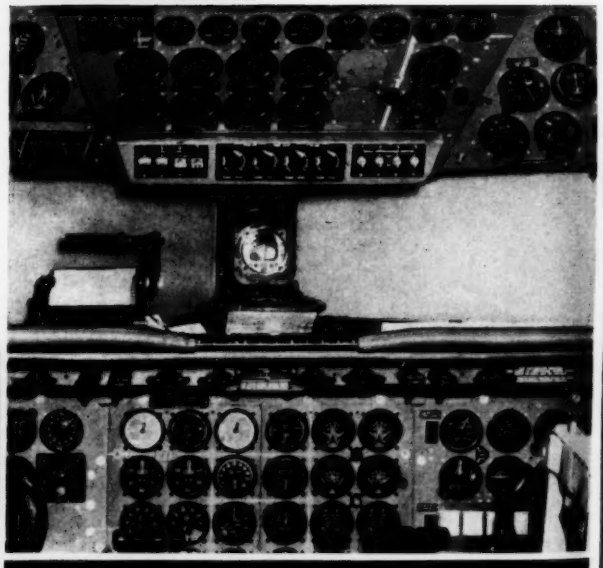

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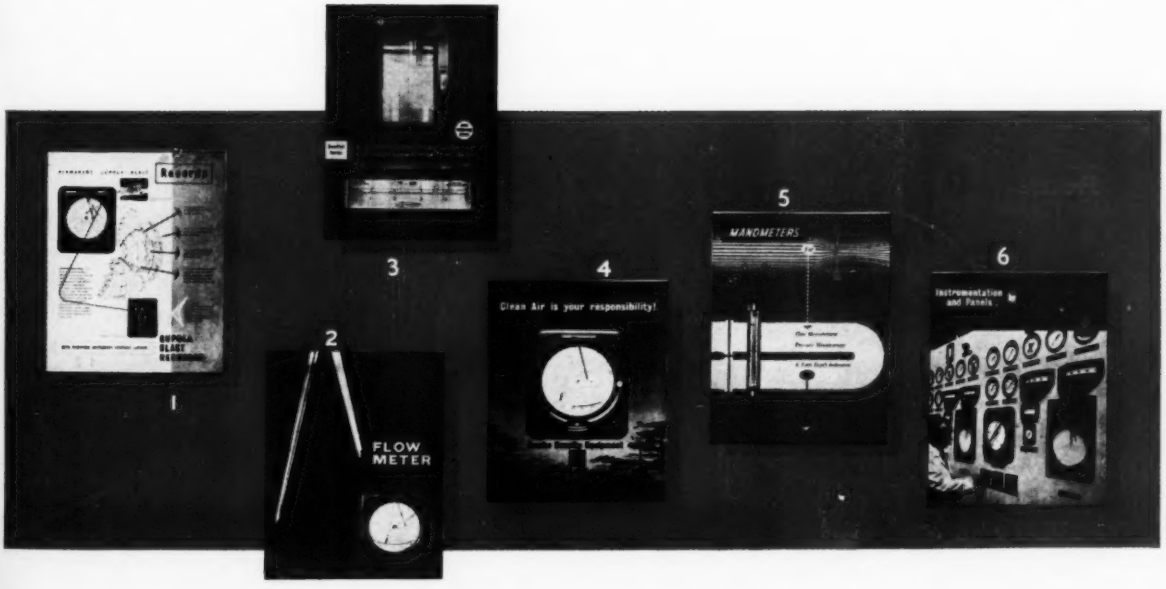

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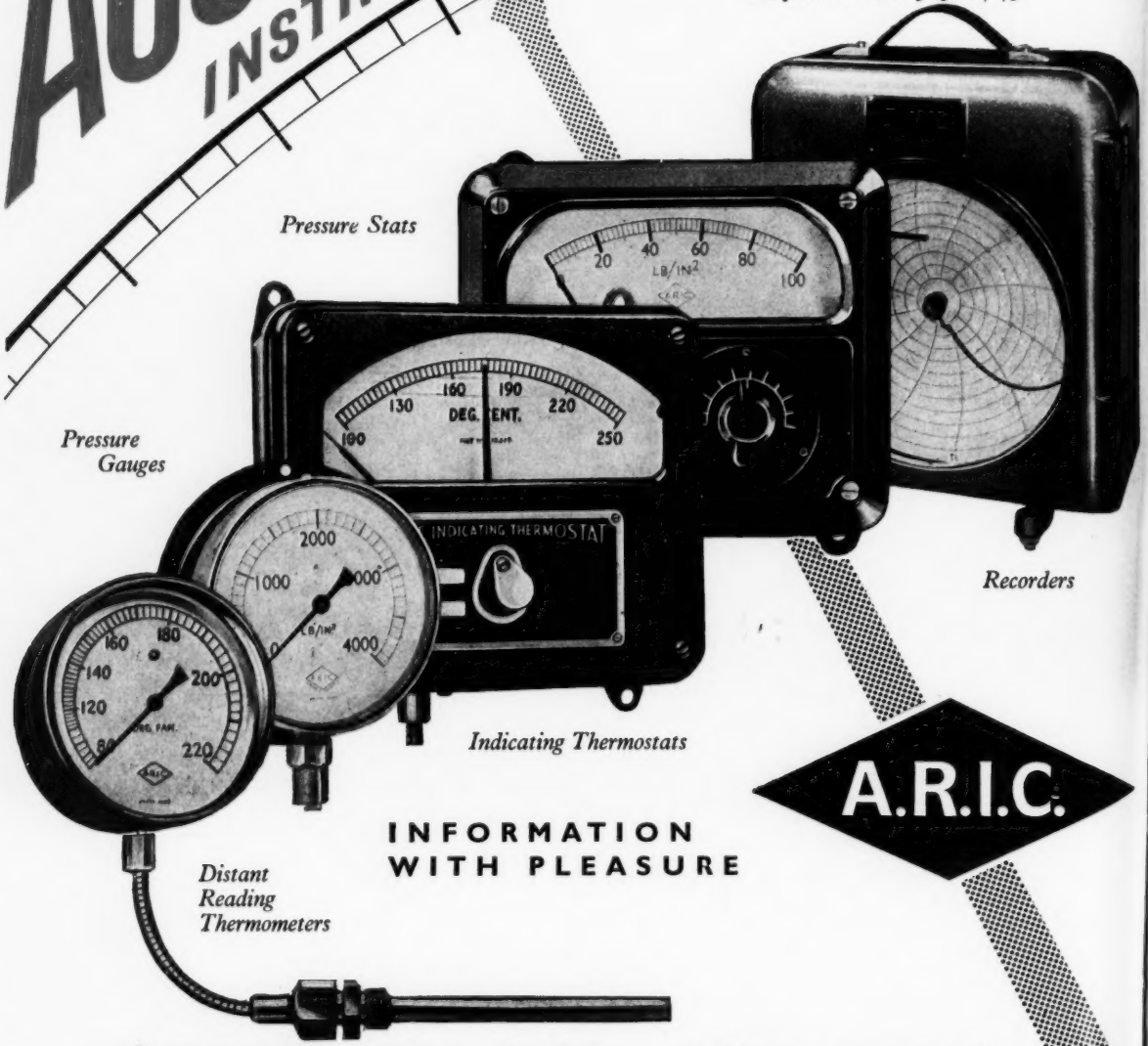

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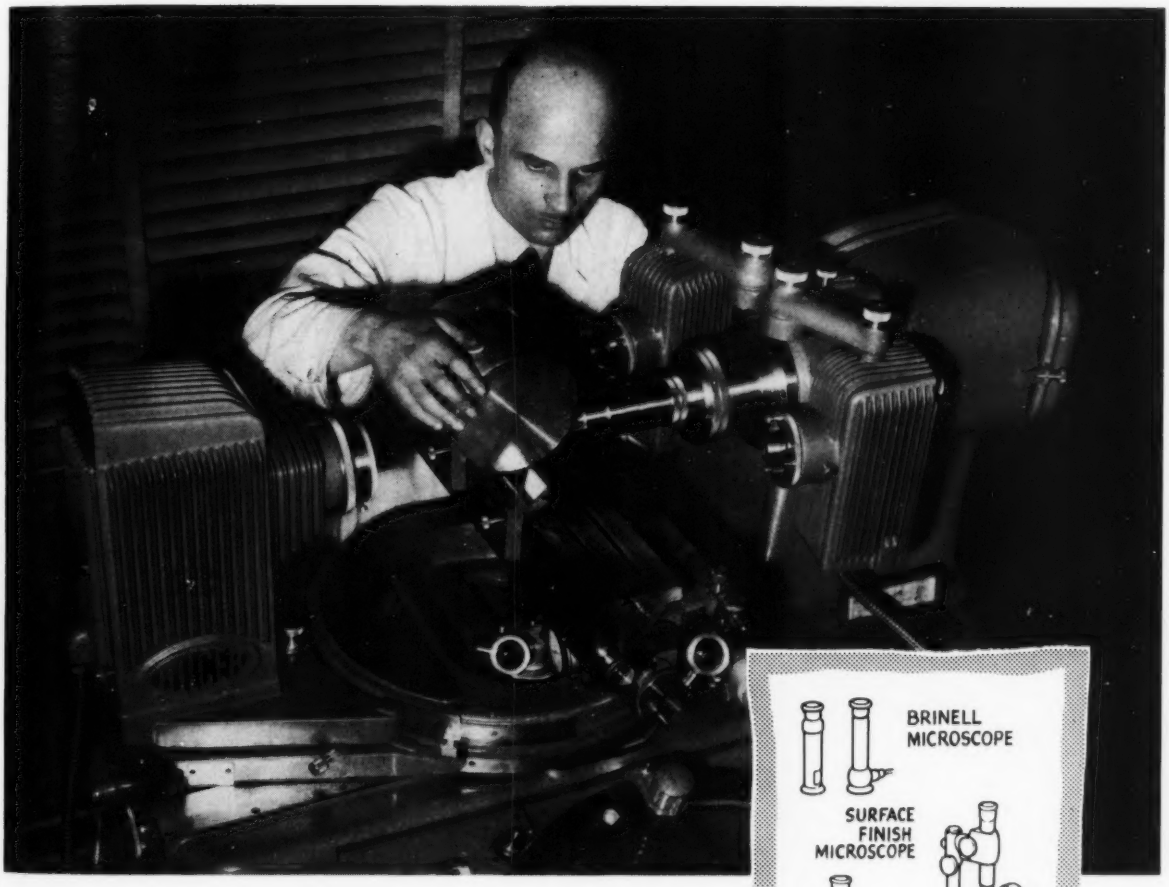
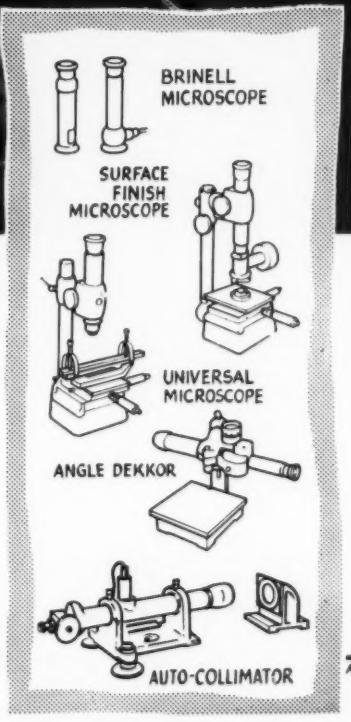
precision measuring instruments





Wide range fulfilling specific requirements in Toolrooms, Machine Shops and Research Establishments. Apart from those instruments illustrated the range includes:—

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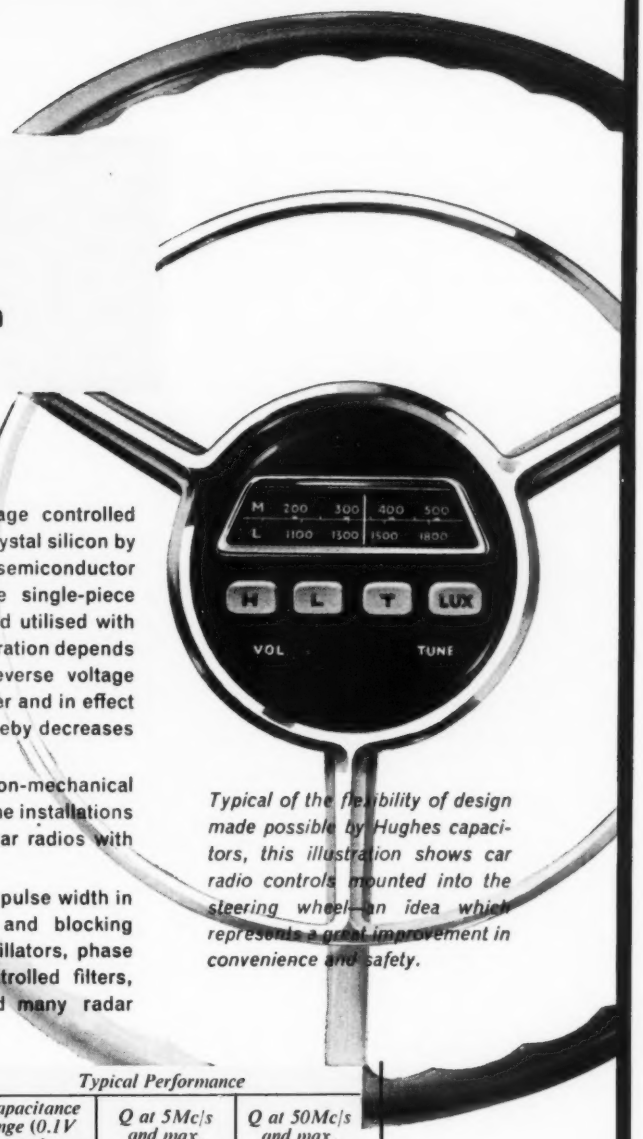
The advantages are tremendous. Precise non-mechanical push-button tuning for pocket radios, more home installations with push-button control in every room, and car radios with simple, precise tuning.

Silicon capacitors can also be used to vary the pulse width in free-running and monostable multivibrators and blocking oscillators. Other applications include RC oscillators, phase and frequency modulators, electronically controlled filters, frequency multipliers, function generators and many radar applications.



Typical of the flexibility of design made possible by Hughes capacitors, this illustration shows car radio controls mounted into the steering wheel—an idea which represents a great improvement in convenience and safety.

	Specification			*Typical Performance*		
Type	*E.I.A. equivalent*	*Capacitance at -4V DC (±20%)*	*Maximum DC Voltage*	*Capacitance range (0.1V to maximum voltage)*	*Q at 5Mc/s and max. voltage*	*Q at 50Mc/s and max. voltage*
HC7001	1N950	35pF	130V	6 to 88pF	360	39
HC7002	1N951	50pF	80V	12 to 120pF	330	36
HC7004	1N952	70pF	60V	20 to 170pF	270	30
HC7005	1N953	100pF	25V	46 to 240pF	200	23
HC7006	1N954	35pF	25V	14 to 88pF	175	20
HC7007	1N955	50pF	25V	22 to 120pF	175	20
HC7008	1N956	70pF	25V	32 to 170pF	175	20

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Actual Size

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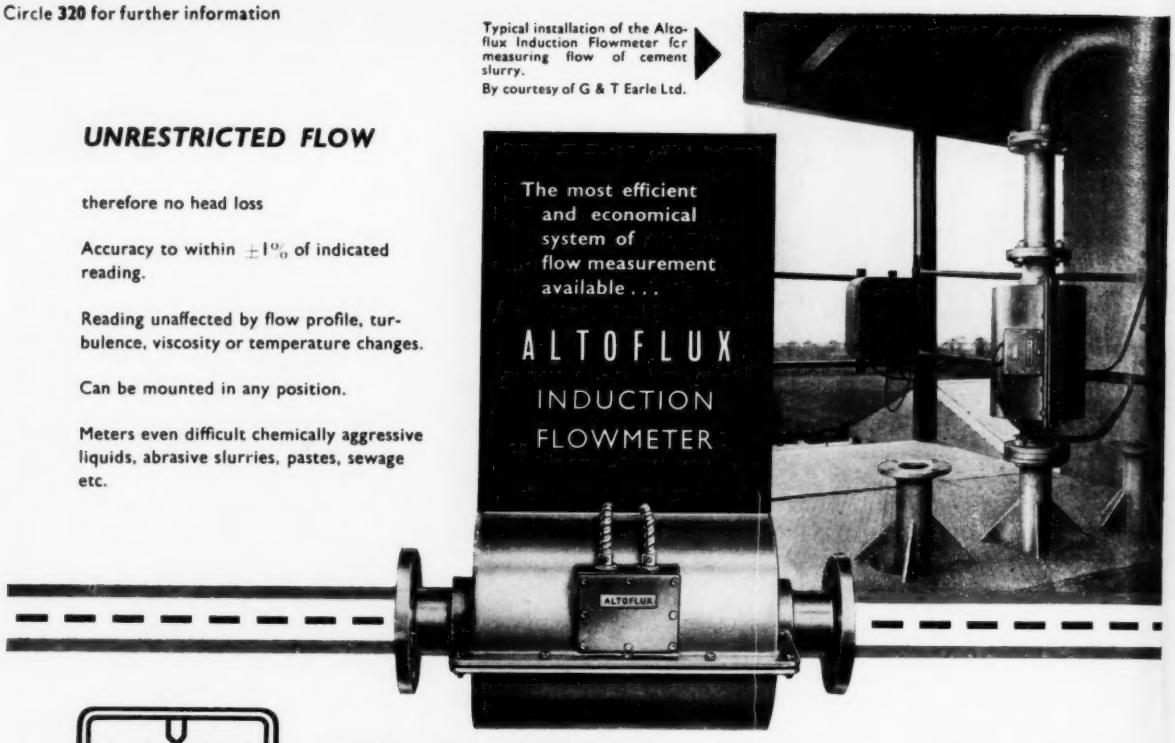
Typical installation of the Altoflux Induction Flowmeter for measuring flow of cement slurry.
By courtesy of G & T Earle Ltd.



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therefore no head loss

Accuracy to within $\pm 1\%$ of indicated reading.

Reading unaffected by flow profile, turbulence, viscosity or temperature changes.

Can be mounted in any position.

Meters even difficult chemically aggressive liquids, abrasive slurries, pastes, sewage etc.

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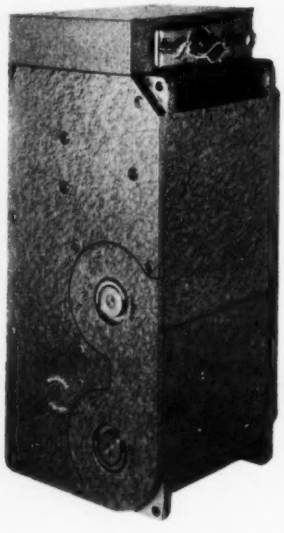

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Circle 322 for further information

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has hitherto been possible only with extensive electronic circuitry—if, in fact, generation was possible at all. Now, with the VLF Function Generator Type SG88, ANY waveshape—mathematical or non-mathematical, no matter how complex or irregular and provided only that it is a single valued function and repetitive—can be generated.

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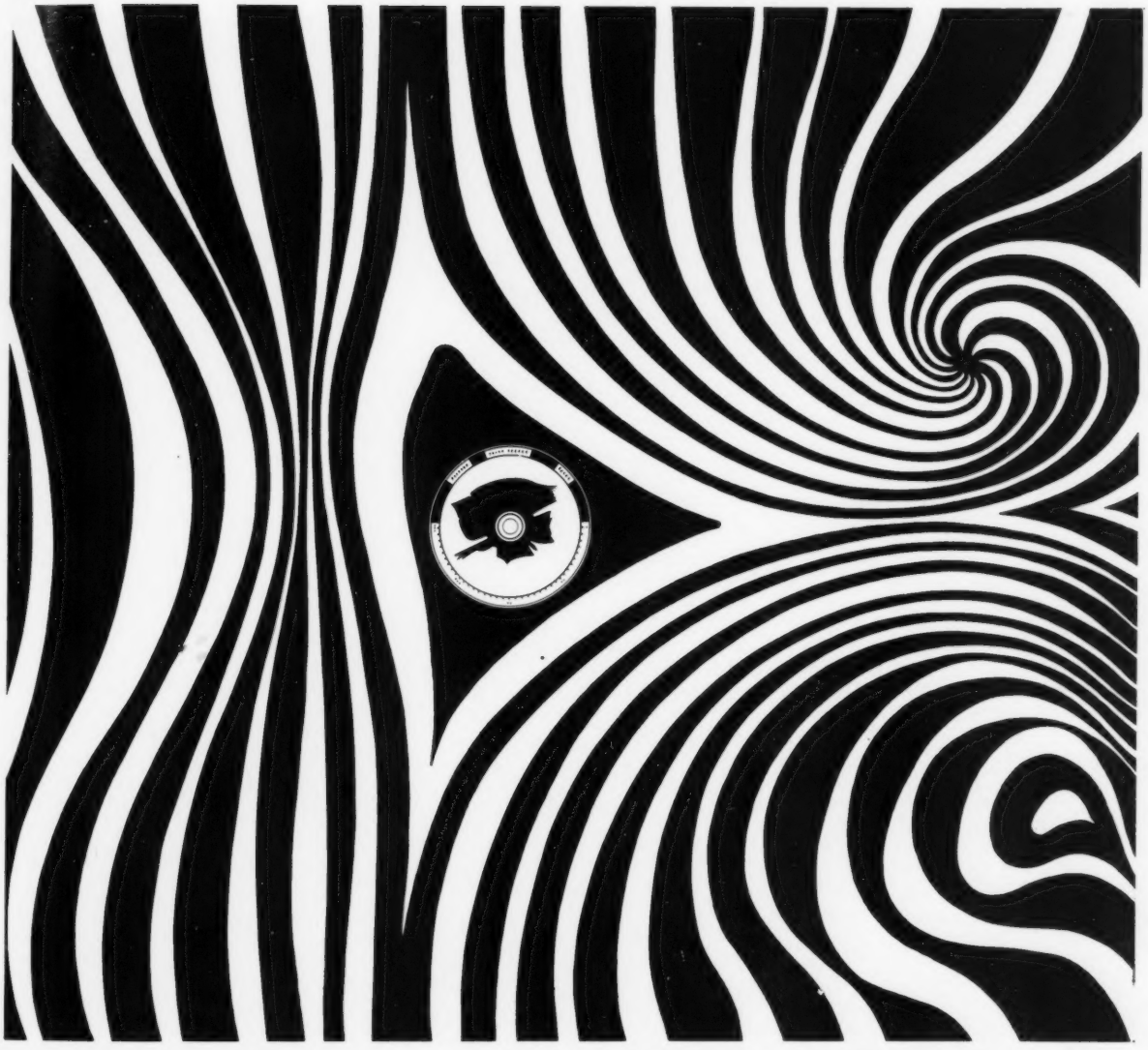

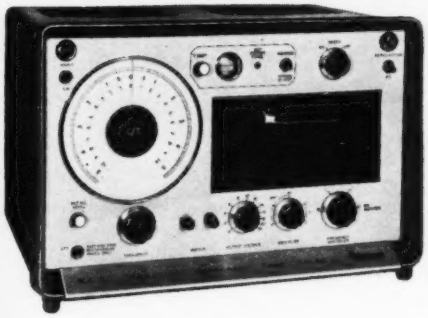

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VLF FUNCTION GENERATOR SG88

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- 3. Frequency Calibration Accuracy: ± 1% Full Scale.
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- 5. Automatic frequency sweep facility.
- 6. Direction of rotation and waveform reversible.
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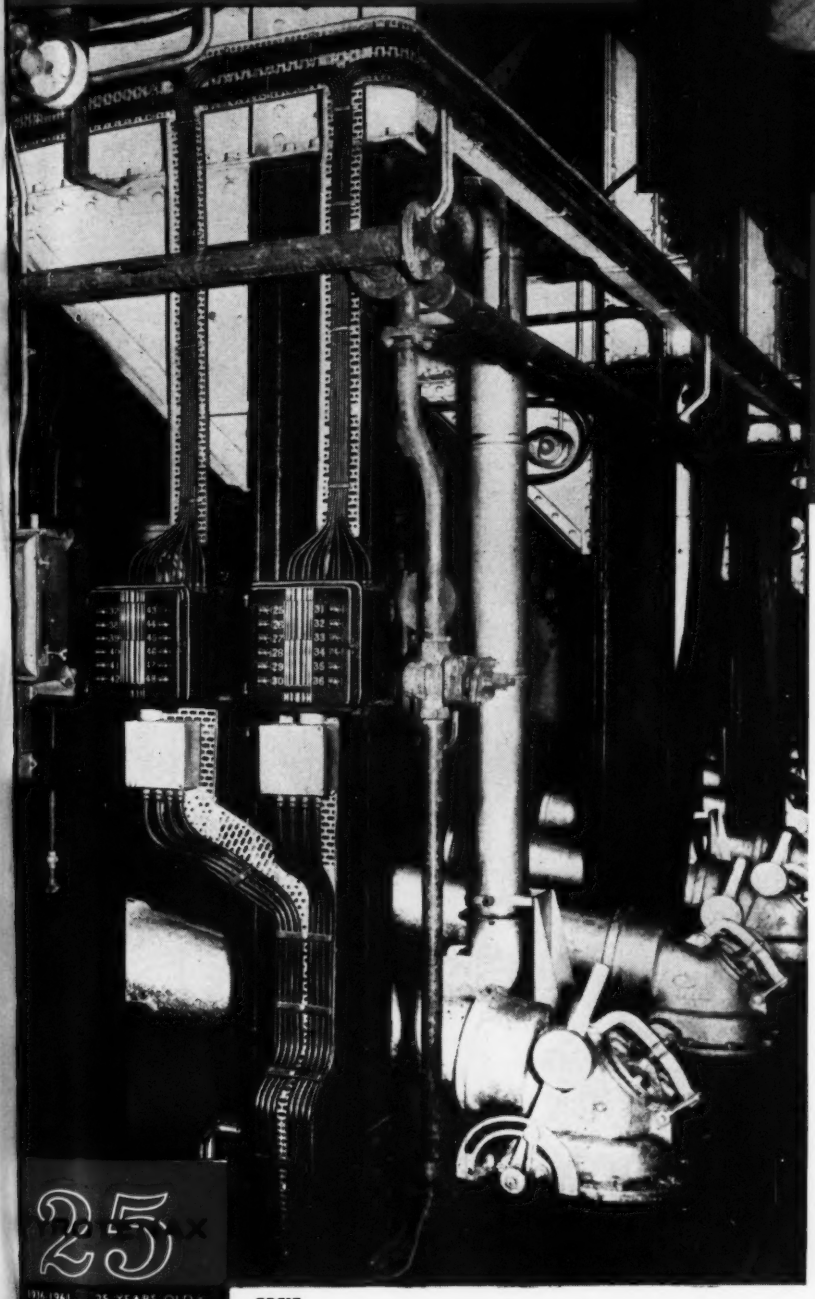

...there is something here for industry!

The top photograph, printed by courtesy of A.E.I.—John Thompson Nuclear Energy Company Limited, a Partner Company of The Nuclear Power Group, shows some of the 982 "Pyrotenax" Thermocouple cables being run off the No. 1 pressure vessel wall at Berkeley Nuclear Power Station.

The reasons that make "Pyrotenax" thermocouples an almost automatic specification for nuclear power stations are equally valid in many industrial applications, and the number of "Pyrotenax" thermocouples and ancillary cables being used by industry is rapidly increasing. The photograph on the left shows "Pyrotenax" compensating cables running from retorts to control panels at the Windsor Street Gas Works, Birmingham.

25
1936-1961 25 YEARS OLD AND AGELESS

GD737

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m.i THERMOCOUPLES

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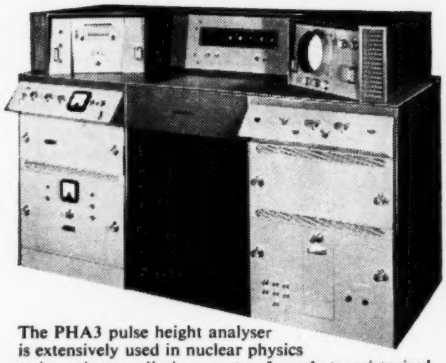
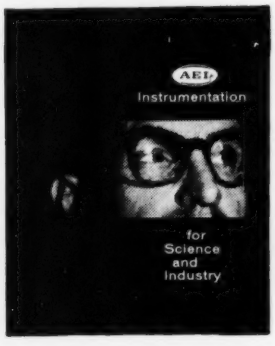


The PHA3 pulse height analyser is extensively used in nuclear physics to investigate radiation spectra. Largely transistorised it has 100 channels each containing ferrite memory storage with a capacity of 65,535 pulses.

Vacuum equipment is essential to many analysis techniques and the "Metrovac" range includes pumps, gauges, valves and accessories. This ionization gauge control unit has a range of 10^{-3} to 10^{-7} mm H.g.



"AEI INSTRUMENTATION FOR SCIENCE AND INDUSTRY"

is the title of a booklet illustrating some of the Division's many activities. Copies are available on request to

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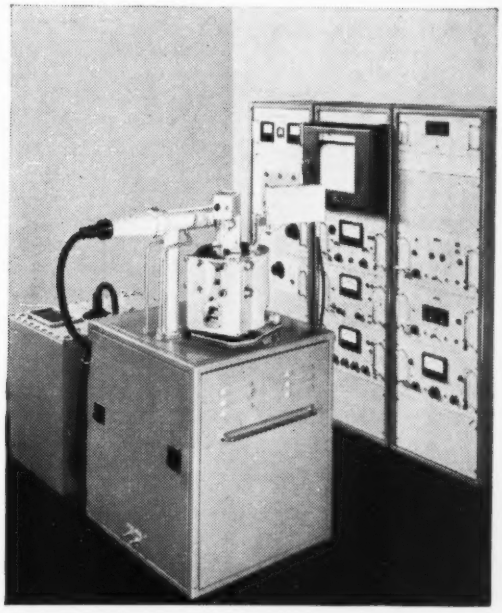
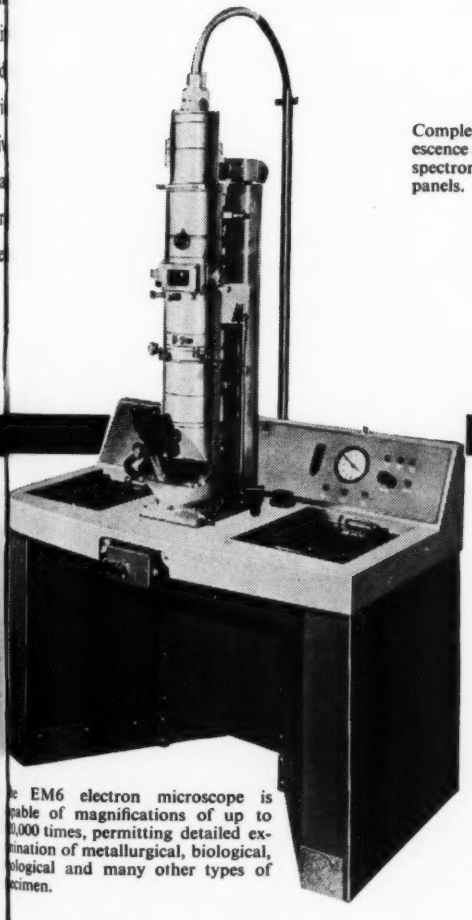
INSTRUMENTATION aids SCIENTIFIC RESEARCH



Complete "Raymax 60" x-ray fluorescence analysis equipment with counter spectrometer and electronic counting panels.



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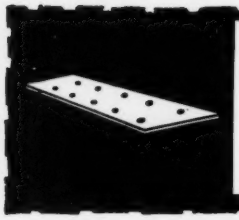

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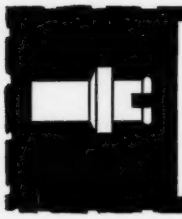
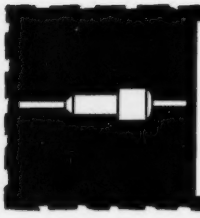


LUGS



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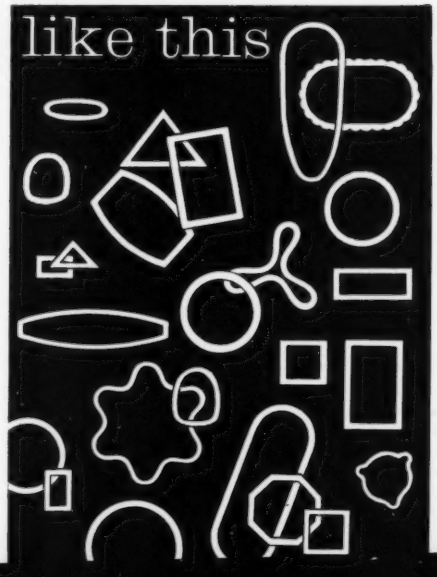

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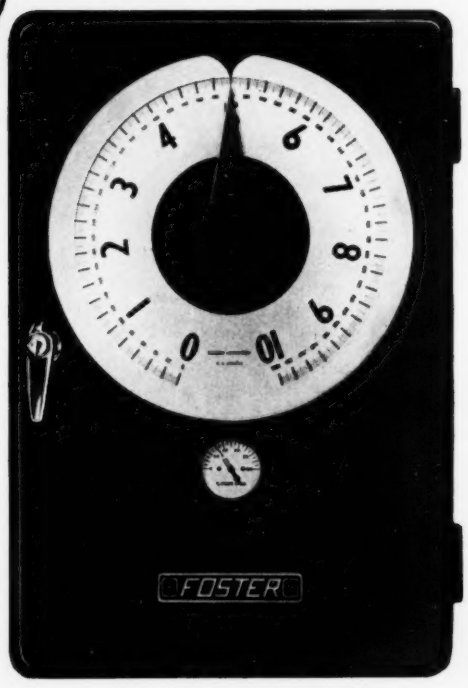
If you have a temperature control problem, may we help you ?



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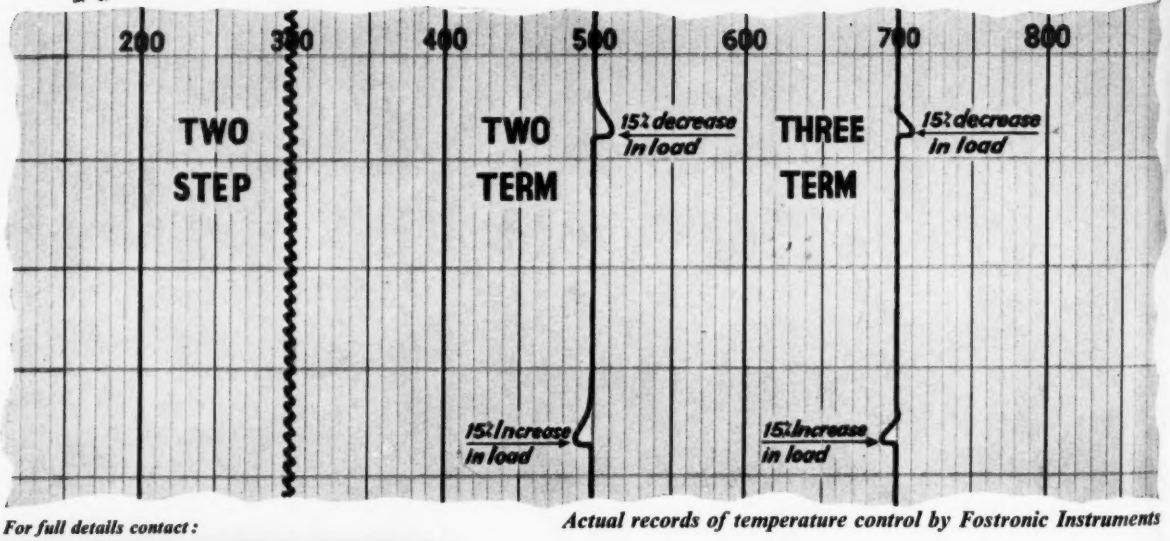

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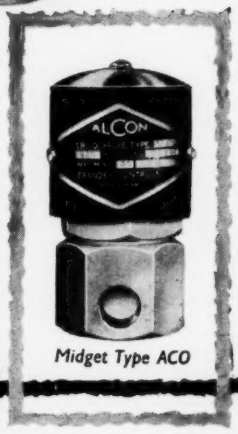
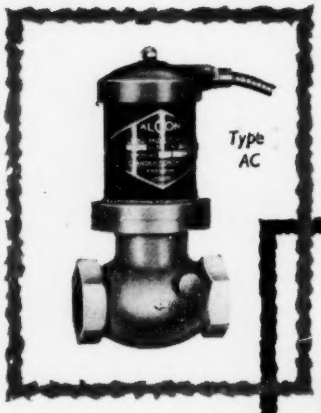
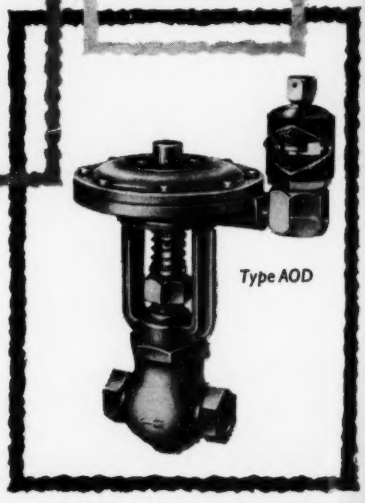


Midget Type ACO



Type AC



Type AOD

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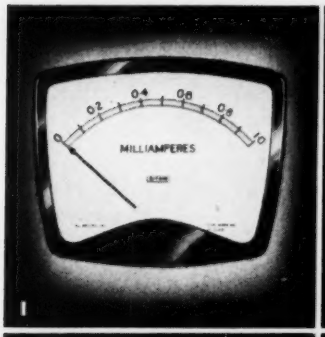

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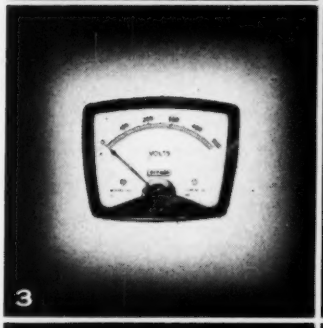
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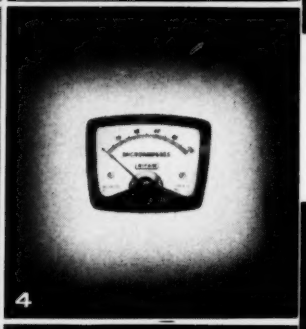
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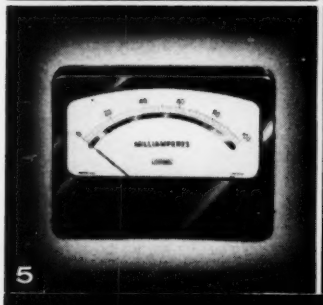
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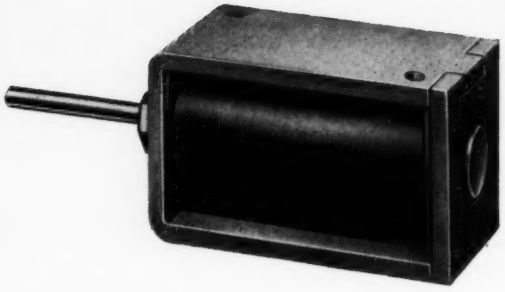

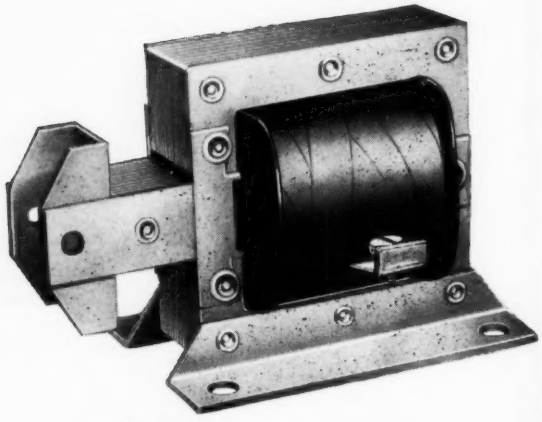

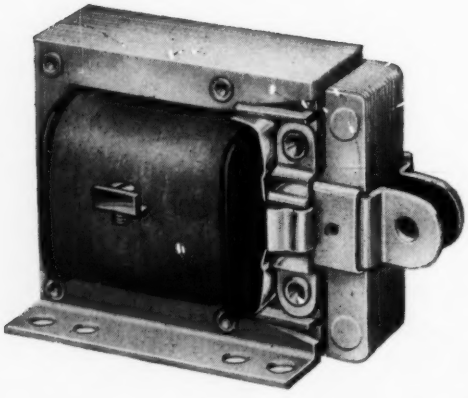

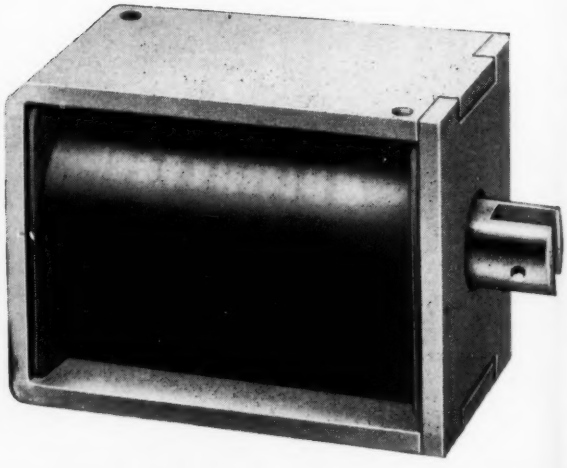

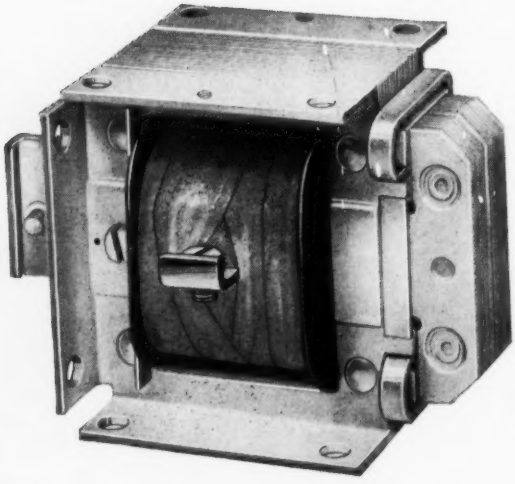

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Now, for little more than the cost of an ordinary moving coil recorder, you can install the Fielden Capacipoise Recorder. The pen and indicating pointer are driven by a robust servo motor and not directly by the moving coil meter. Thus the movement is freed from the load of the pen mechanism yet only a few microwatts input are needed for full scale deflection on the chart and scale.

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TRANSISTORISED for complete reliability. 12 volts D.C. or normal mains operation. No warming-up period. Main electronics housed in sealed plug-in unit. Low power consumption.

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EASY TO INSTALL—Simple clamp panel mounting. Easy access to clearly marked terminals at rear.

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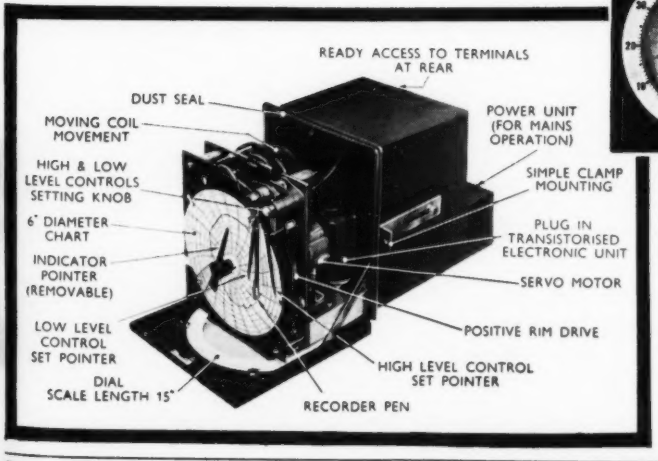
HANDLES WIDE RANGE OF CURRENTS AND VOLTAGES — down to 25 μA or 30 mV D.C. for full scale deflection. A.C. current and voltage ranges also available.



SMOKE DENSITY, pH, CO_2, THICKNESS and FLOW RECORDING. The Fielden Capacipoise Recorder is used with detecting instruments made by many well-known suppliers.

Any variable which can be shown on an indicating meter can be recorded on the Capacipoise Recorder

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This recording is typical of line voltage conditions in an industrial establishment where voltage variation is a problem.

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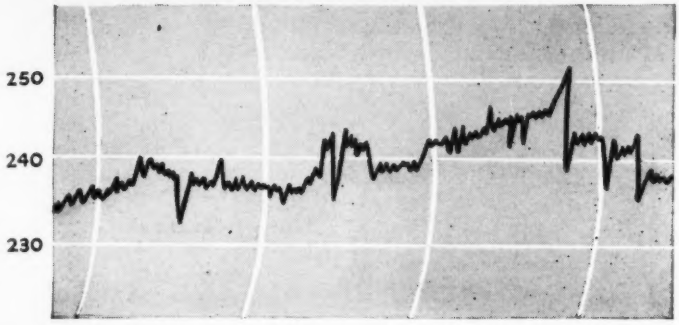
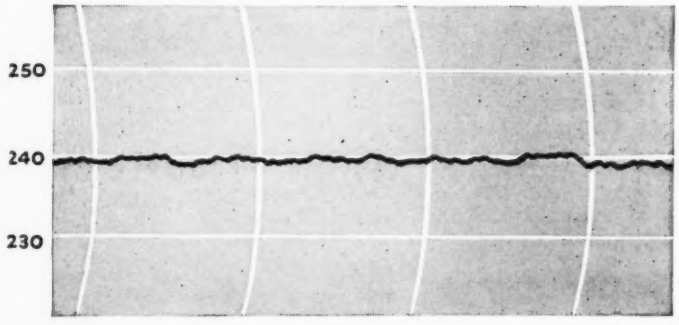
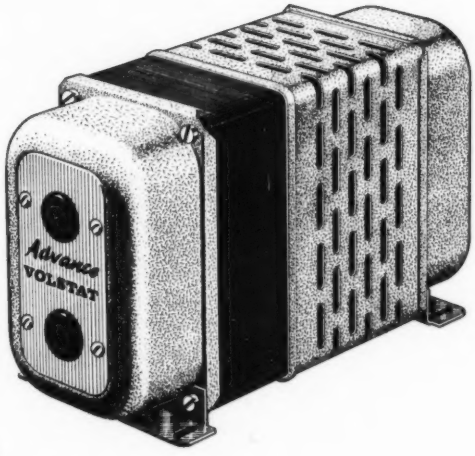


FLUCTUATING VOLTAGE



becomes constant with a

VOLSTAT



A VOLSTAT is the answer to many voltage fluctuation problems. In most cases, a standard type is all that is required—but there are occasions when a special design may be necessary. Either way, an 'Advance' Technical Representative will be pleased to investigate your own particular problems, and recommend a VOLSTAT best suited to your needs. VOLSTAT stands for a complete range of Constant Voltage Transformers produced by 'Advance'— the leading authority on voltage stabilization. Full details in Folder D63 available on request.

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'Then we're too big.'

But you can have Brodie-Kent meters in systems of complete automation, measuring flows of 600 g.p.m. They even handle bitumen.

'But they're gadgets!'

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'Oh . . . well, we can't afford it.'

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Yes. Get in touch with Gilbarco's Technical Advisory Service first—they know all about Brodie-Kent.

'Yes, good idea.'

Look, if you turn over, you'll forget all about it. Do it now.

'You're right, of course. (Are they all like this at Brodie-Kent?)'

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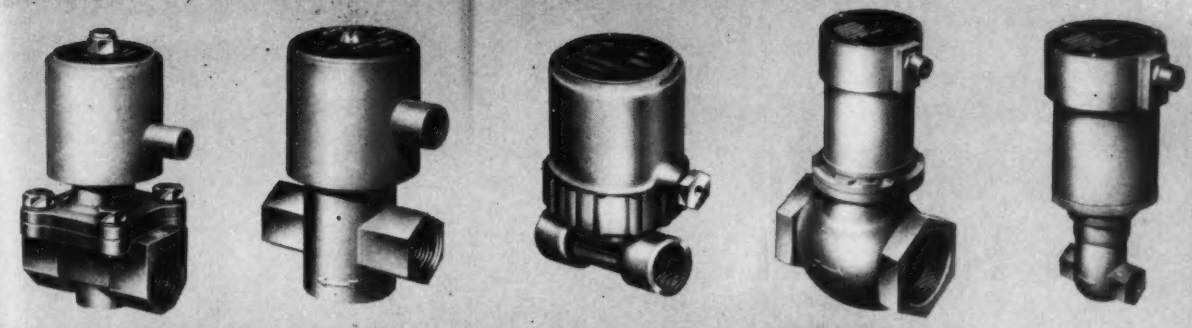

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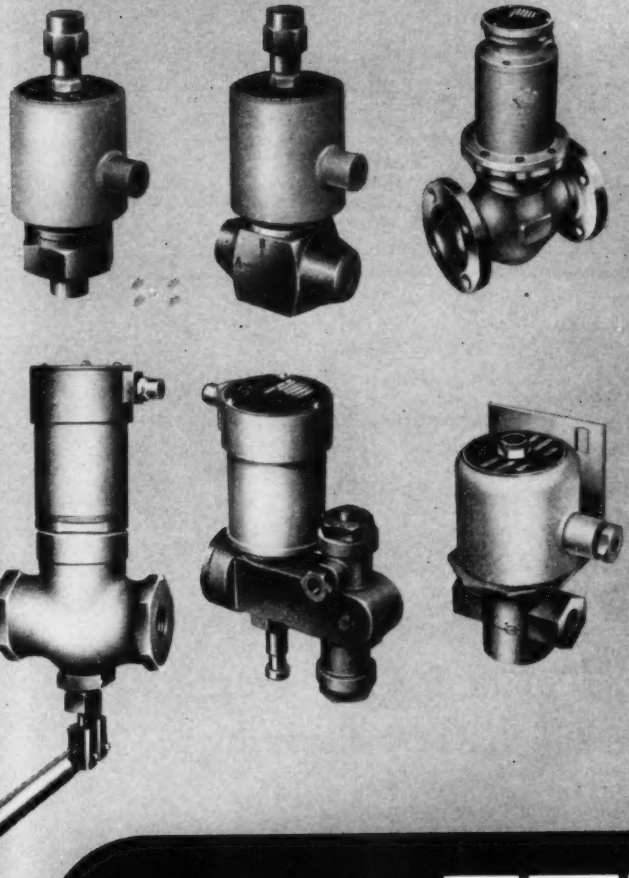

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If the solenoid valves you require are not included in our comprehensive standard ranges, our Design Engineers will gladly develop special types to suit your requirements. Whatever your need, send us your enquiries for prompt attention.

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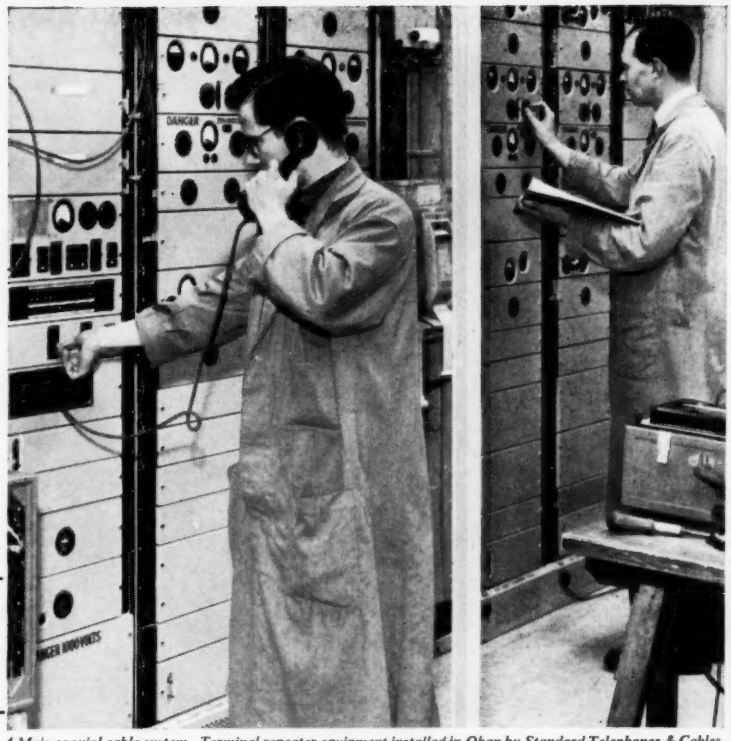
The demand created by the high quality of Weston meters is such that production techniques can be employed which enable these outstanding instruments to be produced at competitive prices.

There can be no finer advertisement for your equipment than the name "Weston" on the meters installed



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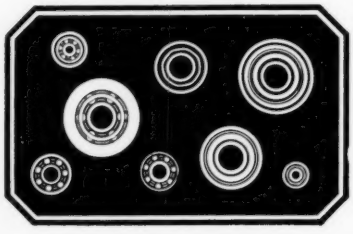

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MINIATURE BEARINGS

ranging in size from 1.5 mm. o.d. upwards.
Also super-precision and sealed ball bearings in several sizes.

FULL PARTICULARS AND SIZES ARE AVAILABLE ON APPLICATION

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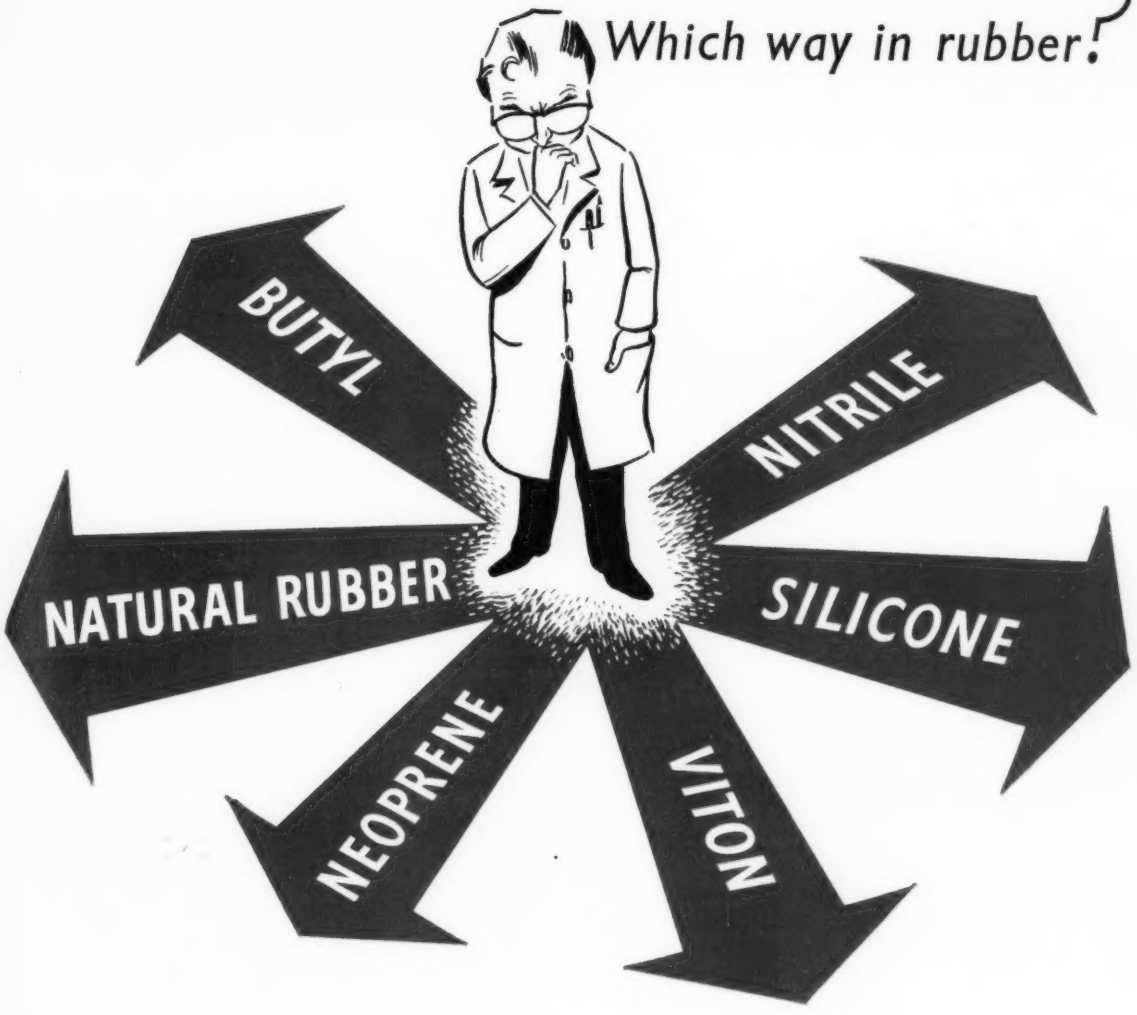

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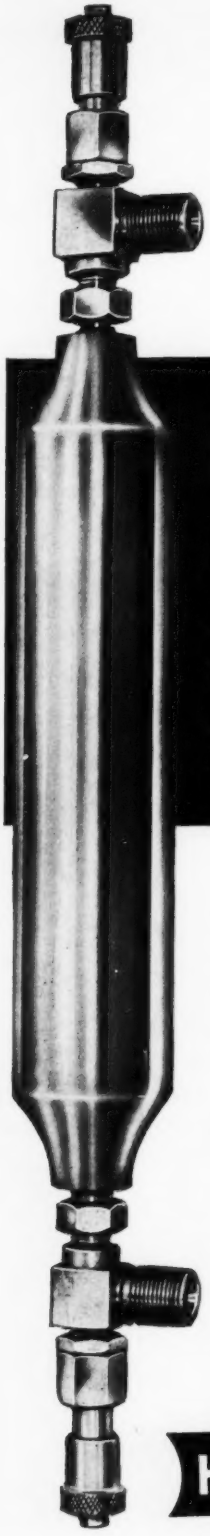
GD 791



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Constructed of seamless 18/8 stainless steel tube and with welded hemispherical ends these bombs are available with capacities from 100 ml to 2½ litre. They are tested to 4,000 p.s.i. and are fitted with nylon-seated stainless steel needle valves with ⅜ in. B.S.P. side connections.

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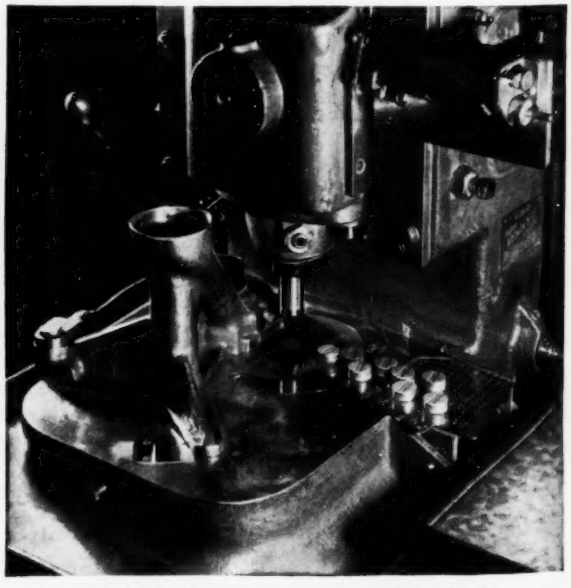
Uniformity of size and performance from one magnet to another is a major feature enabling large quantities to be produced with consistent properties throughout.

Intricate shapes to closely controlled tolerances are possible; surfaces are smooth and, generally, additional machining is unnecessary. Magnets as small as ⅛″ diam. x 1/16″ can be produced and the very nature of the process permits rapid production with low handling costs. Permanent magnets manufactured by this process are now being used on an ever increasing scale in industry. Currently they can be found in high speed generators in aircraft, moving coil instruments, kilowatt hour meters, moving coil and microcurrent relays, hearing aids, miniature microphones, synchronous motors, tachometers, thermostats and small electric motors. Alloys being produced by this process are Alcomax III, Alcomax IV, Hycomax, Alnico and Comalloy.

'Sincomax' is a development of this technique, where magnets and associated iron pole pieces are produced as composite units of high efficiency with no air gaps between magnet and pole pieces and a bond of great mechanical strength. From this originated the 'Sincomax' form of the internal magnet system. Here the magnet replaces the concentrator in the conventional moving coil system. Iron shoes become an integral part of the magnet to give an even distribution of flux.



MUREX LTD. have many years experience in the manufacture of magnets by the Powder Metallurgy technique and qualified technical staff is available to advise on magnet design and performance. Literature can be provided upon request, giving full details of our current range and information relating to design considerations.

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Eminently suitable for measurements in the acoustical and ultrasonic fields, electrical measurements on I.F. and A.F. amplifiers, on carrier telephone installations, and of mechanical vibration.

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Measuring ranges: 1 mV — 300 V f.s.d.
dB scale from — 80 dB . . . 52 dB
0 dB = 1 mW into 600Ω (0.775 V).

Frequency range: 2 c/s . . . 1 Mc/s.

Overall accuracy: 20 c/s . . . 100 kc/s ± 2.5%
2 c/s . . . 1 Mc/s better than ± 5%.

Input impedance: 1 mV to 3 V, 4 MΩ in parallel with 20 pF.
10 V to 300 V, 10 MΩ in parallel with 10 pF.

Mains supply: 110–245 V. 40–100 c/s.

PHILIPS range of Electronic Voltmeters

	Type	*Frequency range*	*AC voltage f.s.d.* *AC current f.s.d.*	*DC voltage f.s.d.* *DC current f.s.d.*	*Input impedance*	
Millivoltmeters	**GM 6020**	DC only	—	100 μV — 1000 V 100 μμA — 10 μA (*d*)	1 MΩ//20 μμF 100 MΩ//10 μμF	Automatic polarity indication by 2 lamps
	GM 6012	2 c/s — 1 Mc/s	1 mV — 300 V (*d*)	—	4 — 10 MΩ// 20 — 10 μμF	Amplifier (60X) can be used simultaneously
	GM 6014	1 kc/s — 30 Mc/s	1 mV — 30 V (*d*)	—	50 kΩ — 50 MΩ// 7 — 2 μμF	
	GM 6025	0·1 Mc/s — 800 Mc/s	10 mV — 10 V (*d*)	—	35 kΩ//1 μμF (*c*)	
Universal voltmeters	**P 817.00**	30 c/s — 10 kc/s	3 V — 1200 V 600 μA — 3 A	60 mV — 1200 V 30 μA — 3 A	AC 1·6 kΩ/V DC 40 kΩ/V	Resistance measurements: 1Ω — 10 MΩ
	GM 6000	20 c/s — 100 Mc/s	1 V — 300 V	1 V — 1000 V	AC 1·0 MΩ/8 μμF DC 10 MΩ (*b*)	Resistance measurements: 10Ω — 5 MΩ
	GM 6009	20 c/s — 100 Mc/s	1 V — 300 V	300 mV — 1000 V 300 μA — 300 mA (*a*)	AC 1·5 MΩ/8 μμF DC 3 — 10 MΩ (*b*)	Resistance measurements: 10Ω — 1000 MΩ
	GM 6058	40 c/s — 1000 Mc/s	1 V — 300 V 1 μA — 1 A	1 V — 1000 V 0·6 μA — 1 A (*a*) (*d*)	AC 2 MΩ/1·5 μμF DC 20 — 30 MΩ (*b*)	Resistance measurements: 1Ω — 1000 MΩ Capacitance measurements 30 μμF — 3 μF

(a) to 30 kV with the aid of the H.T. probe GM 4579B (b) at 1 Mc/s (c) at 200 Mc/s (d) for these ranges internal calibration standard(s) are provided

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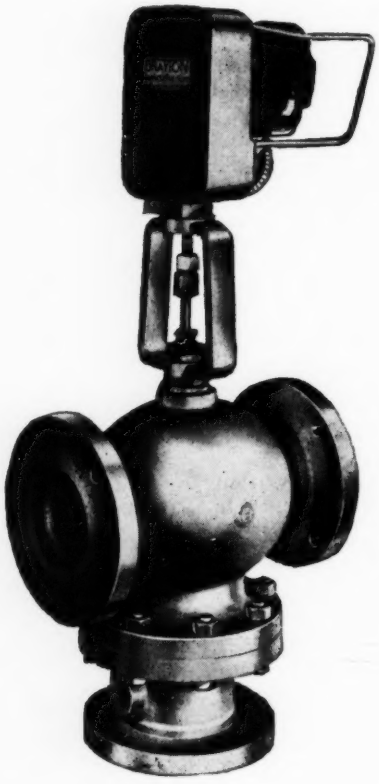
Drayton Service



The unrivalled reliability of Drayton products has given them a record of service that has become a tradition. Associated with it are pre-sales consultation and planning as well as the supply and commissioning of apparatus. Choose wisely, choose Drayton and get unmatched service before and after installation.

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For the control of steam, water, oil, gas or other fluids, a series of on/off and proportioning motorised valves is available in a range of sizes from ½″ to 12″. They are supplied as single seat, double seat, three-way, piston-balanced and butterfly types with unidirectional or reversing motors, the motors incorporating their own programme switches.

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VT Self-operating Controllers

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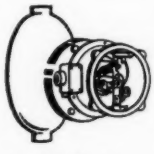

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INSTRUMENT PRACTICE

COMMENTARY

Ultrasonics It is interesting to reflect on the manner in which different frequency regions become significant with the passage of time. For decades, the commercial power generation frequencies of 50 c/s or 60 c/s alone were of industrial interest with, perhaps, a few applications for other frequencies less than 1,000 c/s. Then came broadcasting when the audio frequency band for reproduction and recording and the radio frequency band for transmitting became of intense importance. Television increased the interest into the video frequency region, and the necessity for interference-free sound broadcasting produced developments in the ultra-short wave or ultra high frequency bands. Radar and its subsequent developments, of course, focused attention in another manner to the high frequency region. There is one band of frequencies, however, which has not received a great deal of prominence although research and development in it have been proceeding for some time, and this is ultrasonics which is concerned with frequencies commencing just above the audio frequency limit—say 20 kc/s. The upper limit is somewhat dependent on the generators available, but it can extend to 500 Mc/s or even 1,000 Mc/s.

Readers of this journal will have noted during the last two or three years increasing references to ultrasonic techniques either in the form of technical articles or as descriptions of new products. The increase is not accidental but is the outcome of the search for new methods of measurement, the necessity for which was stressed in the Commentary in last month's issue. Significantly, the Scientific Instrument Manufacturers' Association have recently instituted a committee to investigate problems such as standardisation in ultrasonic methods.

Preliminary information to hand at the time of writing suggests that the range of applications is being extended into rather unexpected fields, and the future may bring some outstanding developments. What has been achieved so far? The following indicate the main fields.

1. Non-destructive testing
2. Echo sounding at sea
3. Industrial measurements
4. Medical
5. Cleaning
6. Soldering
7. Drilling
8. Alarm systems

At the boundary between media of different densities a beam or train of pulses of ultrasonic energy is found to undergo reflection and refraction in a similar manner to light. The reflected beam or pulses becomes of importance in several measurements and illustrates the manner in which a principle, once established, can be successfully applied. First of all, in non-destructive testing an ultrasonic beam or pulse is reflected from a flaw or defect in a specimen of solid material. The position of the reflected pulse relative to reference pulses from the back and front walls of the specimen enable the flaw to be located. Since a pulse may be reflected from the back wall, the principle may be applied to measuring the wall thickness of vessels and pipes. This method, as in flaw detection, involves one side of the object only, an obvious advantage where plant is concerned, and it is desirable to check on walls subject to corrosion or other defects. A reflected pulse technique again is incorporated in measurements of the depths of the sea below a ship. The sea bed may be charted by transmitting ultrasonic pulses down from the ship to the bed and measuring the time elapsing between transmitted pulse and reception of the reflected pulse. The technique has been further applied to the detection of shoals of fish. In yet another field, the reflected pulse idea has been introduced for medical purposes. Short trains of ultrasonic pulses are transmitted into the body and, as well as normal reflections, any diseased tissues show up as additional reflections in a manner broadly similar to flaws in solid materials. It is felt that the technique may assist early diagnostic work.

Turning to industrial measurements we have four examples of interest. The first is the ultrasonic flow meter comprising a dual transmitter and receiver system. The second is a viscometer involving a member vibrating at ultrasonic frequencies. The third is the recently introduced batch counter and general detector in which a beam of ultrasonic energy takes the place of a light beam and photocell. The fourth is a development, as yet in the prototype stage, in which a beam of ultrasonic energy may be used for flame failure detection.

Of the other applications space does not allow more than a brief mention. Ultrasonic energy has proved beneficial in providing means of cleaning inaccessible places and very small parts. We have the ultrasonic vibration of parts to remove oxide and facilitate soldering. Drilling of glass and similar materials can be carried out rapidly by ultrasonic drills.

The foregoing are very diversified applications, and certainly indicate that ultrasonic techniques need not be confined to a narrow field. We shall look forward to future developments in a field of which the surface is barely scratched.

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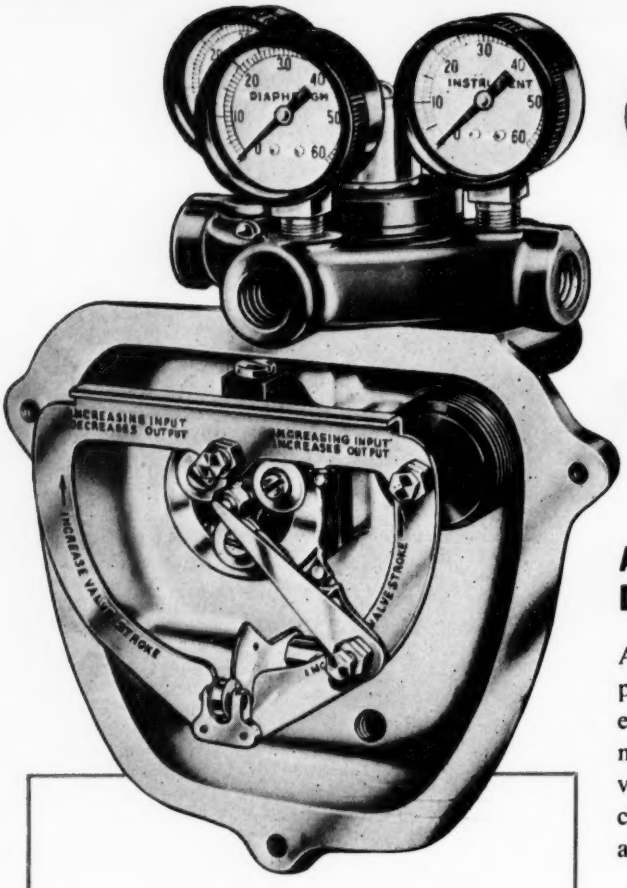

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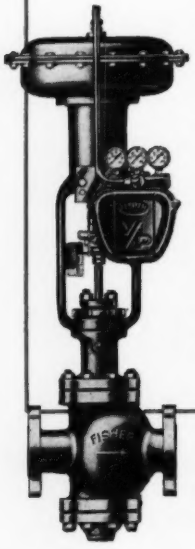

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FG12

Static and Dynamic Analysis of the Transistor as a Switch

Part 1. Static Behaviour

By G. H. PARKS, B.Sc., M.I.E.E.*

Summary

Theoretical expressions for both the static and dynamic behaviour of the transistor as a switch are developed which illustrate the basic principles involved and enable the performance to be predicted with an accuracy which is sufficient for the selection of the most suitable type of transistor for a given application.

1. Introduction

THE ideal switch possesses zero impedance when closed and infinite impedance when open. Thus its static characteristic would consist of two straight lines at right angles, one coincident with the current axis representing the closed condition and one coincident with the voltage axis representing the open condition. The somewhat idealised static characteristic of an alloy junction transistor in the common emitter connection shown in Fig. 1 illustrates the fact that the two boundaries to this characteristic approximate fairly closely to the current axis in one case and the voltage axis in the other. The degree to which the actual characteristic of a transistor approaches the ideal depends upon the type of transistor and on the conditions which are imposed by the external circuit.

In general the transistor acting as a closed, switch may be represented by a battery in series with a low resistance and, when acting as an open switch, by a current generator in parallel with a high resistance. The presence of the series resistor and battery represent the departure from the zero resistance of the ideal switch in the closed condition, and the current generator and shunt resistor the departure from the infinite resistance of the ideal switch in the open condition.

From theoretical considerations expressions will be derived from which the magnitudes of the e.m.f. of the voltage generator, of the short circuit current of the

*Telecommunications Section 1. Associated Electrical Industries (Woolwich) Ltd.

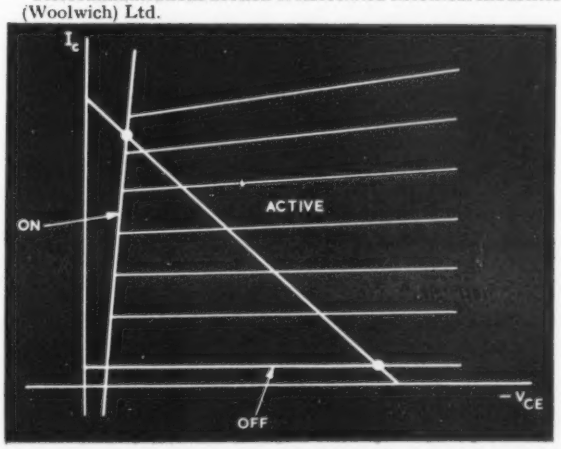


Fig. 1. Static characteristic of an alloy junction transistor in the common emitter connection

current generator and of the series resistance can be calculated.

A switch is not fully specified unless the times of transfer from the OFF to the ON state, and from the ON state to the OFF state are also known. Expressions will be developed which will enable these switching times to be calculated for different circuit conditions from known transistor parameters.

2. Static Behaviour

2.1 *Theoretical Analysis*

The large signal behaviour of a p-n junction transistor can be explained in terms of an interaction between two diodes connected back to back, as has been shown by Ebers and Moll[1]. The equations obtained are based on the assumed current-voltage relationship for a p-n junction expressed by the equation:

$$I = I_s \exp(qVkT) - 1 \quad \ldots\ldots\ldots\ldots (1)$$

where k is Boltzmann's constant, q is the electronic charge, T is the absolute temperature, V is the potential across the junction and I_s is the reverse saturation current.

The form of the equation is shown in Fig. 2 and will be recognised as typical of a wide range of p-n junction diodes.

In a p-n junction transistor a common base region is shared by the emitter-base junction and the base-collector junction. If we assume that a fraction α_n of the current injected across the emitter-base junction reaches the collector and also that a fraction α_i of the current injected across the collector-base junction reaches the emitter, then the equivalent circuit shown in Fig. 3 can be drawn to represent the large signal behaviour at low frequencies.

The relevant equations are

$$I_e = I_{ef} - \alpha_i I_{cf} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$I_c = I_{cf} - \alpha_n I_{ef} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

I_{ef} and I_{cf} are p-n junction currents and can therefore be expressed in the form given by (1).

We can therefore write

$$I_{ef} = I_{es}[\exp(qV_{eb'}/kT) - 1] \quad \ldots\ldots\ldots (4)$$

$$I_{cf} = I_{cs}[\exp(qV_{cb'}/kT) - 1] \quad \ldots\ldots\ldots (5)$$

Equations (2) and (3) can now be written in the form

$$I_e = I_{es}[\exp(qV_{eb'}/kT) - 1] - \alpha_i I_{cs}[\exp(qV_{cb'}/kT) - 1] \quad \ldots (6)$$

$$I_c = I_{cs}[\exp(qV_{cb'}/kT) - 1] - \alpha_n I_{es}[\exp(qV_{eb'}/kT) - 1] \quad \ldots (7)$$

These equations will hold under all conditions of bias of the two junctions.

There are three regions of operation which are of interest when the transistor is used as a switch. These are the OFF state, the ACTIVE state and the ON state.

2.1.1 Normal Operation

2.1.1.1 *Off State*

In this state both the emitter-base and collector-base junctions are reverse biased. This corresponds to the line labelled OFF on the characteristic in Fig. 1 and represents the behaviour of the transistor as a switch in the open position. This condition is obtained if both $V_{eb'}$ and $V_{cb'}$ are negative and large compared with kT/q, where kT/q $\doteq$ 26 mV at normal room temperature. As a result the exponential terms in equations (6) and (7) can be neglected compared with unity and (6) and (7) reduce to

$$I_e = -I_{es} + \alpha_i I_{cs} \quad \ldots\ldots\ldots\ldots\ldots (8)$$

$$I_c = -I_{cs} + \alpha_n I_{es} \quad \ldots\ldots\ldots\ldots\ldots (9)$$

But from the symmetry requirements of equations (6) and (7)

$$\alpha_i I_{cs} = \alpha_n I_{es} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

which on substitution in (8) and (9) lead to

$$I_e = -I_{es}(1 - \alpha_n) \quad \ldots\ldots\ldots\ldots\ldots (11)$$

$$I_c = -I_{cs}(1 - \alpha_i) \quad \ldots\ldots\ldots\ldots\ldots (12)$$

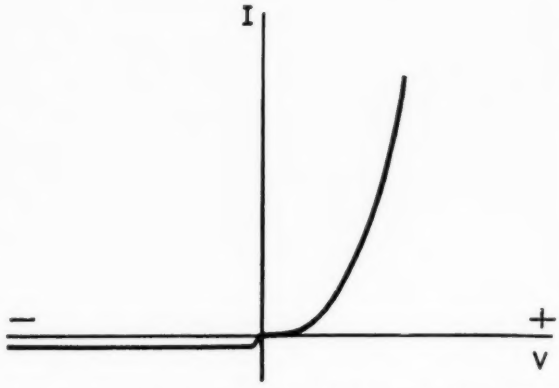


Fig. 2. Current-voltage relationship for a p-n junction

These currents correspond to those designated $I_{e(sim)}$ and $I_{c(sim)}$ by Chaplin and Owens[2], i.e. the currents which flow when both emitter-base and collector-base junctions are simultaneously reverse biased. $I_{e(sim)}$ and $I_{c(sim)}$ can also be written in terms of the more familiar currents I_{co} and I_{eo} where I_{co} = saturation current of the collector-base junction with zero emitter current, and I_{eo} = saturation current of the emitter-base junction with zero collector current.

Using equations (6) and (7) and applying the conditions in the one case, $I_e = 0$ and $V_{cb'}$ is negative and large compared with kT/q to obtain I_{co} and in the other, $I_c = 0$ and $V_{eb'}$ is negative and large compared with kT/q to obtain I_{eo} we find that

$$I_{eo} = -I_{es}(1 - \alpha_n \alpha_i) \quad \ldots\ldots\ldots\ldots\ldots (13)$$

$$I_{co} = -I_{cs}(1 - \alpha_n \alpha_i) \quad \ldots\ldots\ldots\ldots\ldots (14)$$

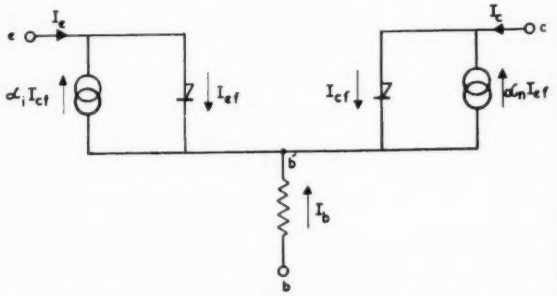


Fig. 3. Equivalent circuit representing the large signal behaviour of a p-n junction at low frequencies

Substituting these in (11) and (12) we obtain:

$$I_{e_{(sim)}} = \frac{I_{eo}}{1-\alpha_n\alpha_i}(1-\alpha_n) \quad \ldots\ldots\ldots\ldots (15)$$

$$I_{c_{(sim)}} = \frac{I_{co}}{1-\alpha_n\alpha_i}(1-\alpha_i) \quad \ldots\ldots\ldots\ldots (16)$$

2.1.1.2 *Active State*

In this state the emitter-base junction is forward biased and the collector-base junction is reverse biased. This corresponds to the region labelled ACTIVE in Fig. 1 and represents the behaviour of the transistor as a switch in passing between the open and closed positions.

This condition is obtained if $V_{eb'}$ is positive and $V_{cb'}$ is negative and large compared with kT/q. Equations (6) and (7) then take the form

$$I_e = I_{es}[\exp(qV_{eb'}/kT) - 1] + \alpha_i I_{cs} \quad \ldots\ldots (17)$$

$$I_c = -I_{cs} - \alpha_n I_{es}[\exp(qV_{eb'}/kT) - 1] \quad \ldots\ldots (18)$$

These equations reduce to

$$I_c = -I_{cs}(1-\alpha_n\alpha_i) - \alpha_n I_e \quad \ldots\ldots\ldots\ldots (19)$$

$$I_c = I_{co} - \alpha_n I_e \quad \text{from (14)} \quad \ldots\ldots\ldots\ldots (20)$$

The most commonly used connection, however, is the common emitter connection because appreciable current gain is available in this connection between the current in the base and the current at the collector. This means that the current being switched in the collector can be controlled by a much smaller current in the base. An expression is therefore required relating the current in the collector to that in the base.

From Fig. 3 we have

$$I_e + I_c + I_b = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (21)$$

Hence, substituting in (20)

$$I_c = I_{co} + \alpha_{i'}(I_c + I_b)$$

which gives

$$I_c = \frac{\alpha_n}{1-\alpha_n} I_b + \frac{I_{co}}{1-\alpha_n} \quad \ldots\ldots\ldots\ldots (22)$$

2.1.1.3. *On State*

In this state both the emitter-base and collector-base junctions are forward biased. This corresponds to the line labelled ON in Fig. 1 and represents the behaviour of the transistor as a switch in the closed position. This condition is obtained if both $V_{eb'}$ and $V_{cb'}$ are positive and large compared with kT/q. Equations (6) and (7) may now be written

$$I_e = I_{es}\exp(qV_{eb'}/kT) - \alpha_i I_{cs}\exp(qV_{cb'}/kT). \quad (23)$$

$$I_c = I_{cs}\exp(qV_{cb'}/kT) - \alpha_n I_{es}\exp(qV_{eb'}/kT) \quad (24)$$

Hence:

$$\exp(qV_{eb'}/kT) = \frac{I_e + \alpha_i I_c}{I_{es}(1-\alpha_n\alpha_i)} \quad \ldots\ldots\ldots (25)$$

$$\exp(qV_{cb'}/kT) = \frac{I_c + \alpha_n I_e}{I_{es}(1-\alpha_n\alpha_i)} \quad \ldots\ldots\ldots (26)$$

and thus,

$$V_{ec} = V_{eb'} - V_{cb'} = \frac{kT}{q}\log_e \frac{I_e + \alpha_i I_c}{I_c + \alpha_n I_e}\cdot\frac{I_{cs}}{I_{es}}$$

$$= \frac{kT}{q}\log_e \frac{I_e + \alpha_i I_c}{I_c + \alpha_n I_e}\cdot\frac{\alpha_n}{\alpha_i} \quad \text{from (10)} \quad \ldots (27)$$

If we now calculate the value of V_{ec}, the voltage drop between emitter and collector when $I_c = 0$, we shall

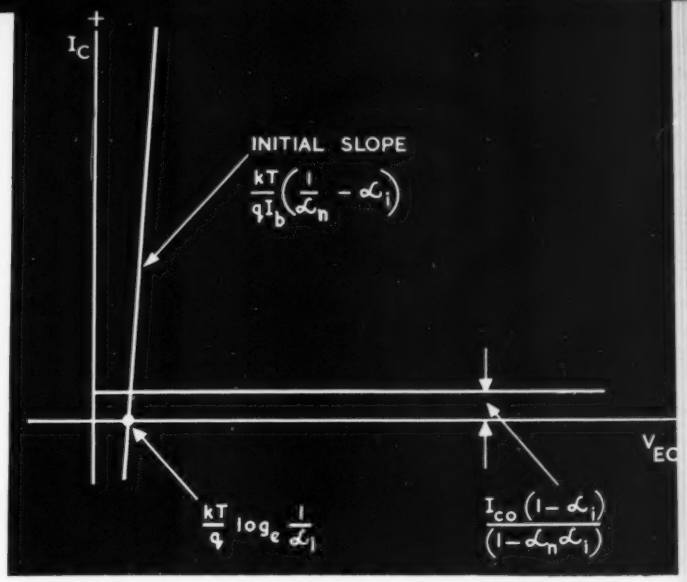


Fig. 4. Voltage-current relationship for the transistor as a switch

then obtain the value of the e.m.f. of the battery in the equivalent circuit of the transistor as a switch in the closed position as shown in Fig. 4.

We thus have,

$$V_{ec}\,{}_{(I_c = 0} = \frac{kT}{q}\cdot\log\frac{1}{\alpha_i} \quad \ldots\ldots\ldots\ldots (28)$$

To obtain the value of the effective resistance in series with the battery as shown in Fig. 4, the expression for V_{ec} must be differentiated with respect to I_c, with I_b held constant. This latter condition must be observed as both Fig. 1 and Fig. 4 relate to the common emitter connection and the line in Fig. 4 is the boundary of a number of curves each with the base current held constant.

Equation (27) must therefore be re-formed in terms of I_c and I_b instead of I_c and I_e. This can be done with the aid of equation (21).

Thus we have,

$$V_{ec} = \frac{kT}{q}\log_e - \frac{I_c(-\alpha_i + 1) + I_b}{I_c(1-\alpha_n) - \alpha_n I_b}\cdot\frac{\alpha_n}{\alpha_i} \quad \ldots (29)$$

Hence,

$$\frac{\partial V_{ec}}{\partial I_{e_{(I_b = \text{const.})}}} = \frac{kT}{q}\cdot\frac{I_c(1-\alpha_n) - \alpha_n I_b}{I_c(1-\alpha_i) + I_b}\cdot\frac{\alpha_n}{\alpha_i}\cdot\frac{\alpha_i}{\alpha_n}\left[\ldots\right]$$

where the expression in the brackets is,

$$\frac{\{I_c(1-\alpha_n) - \alpha_n I_b\}(1-\alpha_i) - \{I_c(1-\alpha_i) + I_b\}(1-\alpha_n)}{\{I_c(1-\alpha_n) - \alpha_n I_b\}^2}$$

and so,

$$\frac{\partial V_{ec}}{\partial I_{e(I_b = \text{const.})}} = \frac{kT}{q}\cdot\frac{-\{I_b\alpha_n(1-\alpha_i) + (1-\alpha_n)\}}{\{I_c(1-\alpha_i) + I_b\}\{I_c(1-\alpha_n) - \alpha_n I_b\}} \quad \ldots (30)$$

Therefore

$$\frac{\partial V_{ec}}{\partial I_{c(I_c = 0)}} = \frac{kT}{qI_b}\left(\frac{1}{\alpha_n} - \alpha_i\right) \quad \ldots\ldots\ldots (31)$$

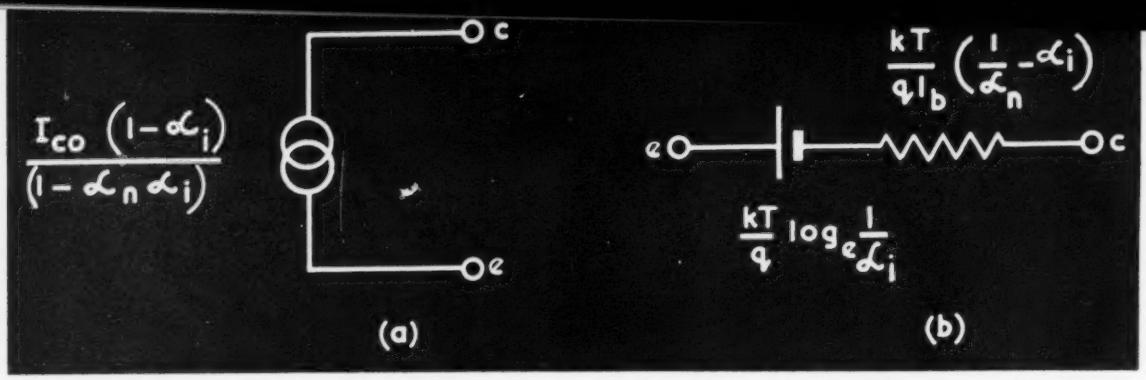


Fig. 5(a). Equivalent circuit for the transistor behaving as an open switch

Fig. 5(b). Equivalent circuit for the transistor behaving as a closed switch

2.1.1.4 *Summary of Normal Operation Behaviour*

We can thus see that the theoretical equations predict that when the transistor behaves as an open switch a saturation current $\frac{I_{co}(1-\alpha_i)}{(1-\alpha_n\alpha_i)}$ will flow across the " contacts " as shown in Fig. 5(a). Because the basic diode equation assumes that in the reverse biased condition the resistance across the diode is infinite, a value for the resistance between the " contacts " of the transistor when in the open condition cannot be obtained from the theoretical equations.

When the transistor behaves as a closed switch, the theoretical equations predict that the e.m.f. of the equivalent battery is $\frac{kT}{q}\log\frac{1}{\alpha_i}$ and the effective series resistance is $\frac{kT}{qI_b}\left(\frac{1}{\alpha_n}-\alpha_i\right)$ as shown in Fig. 5(b).

Equation (22) also shows that the current which can be controlled in the collector circuit is approximately $\frac{\alpha_n}{1-\alpha_n}$ times the controlling current in the base circuit. However, for a low value of series resistance to be obtained in the closed condition of the switch both junctions must be in the forward biased condition as explained in Section 2.1.1.3.

Equations (23) and (24) can be combined to obtain an equation similar to (22) thus

$$I_c = I_{cs}(1-\alpha_n\alpha_i)\exp(qV_{cb'}/kT) - \alpha_n I_e \quad \ldots \quad (32)$$

which on substituting from (21) and (14) becomes

$$I_c = \frac{I_{co}}{1-\alpha_n}\exp(qV_{cb'}/kT) + \frac{\alpha_n}{1-\alpha_n} I_b \quad \ldots \quad (33)$$

Remembering that we are considering the ON state in which $V_{cb'}$ is positive and large compared with kT/q the term $-\frac{I_{co}}{1-\alpha_n}\exp(qV_{cb'}/kT)$ is of opposite sign and obviously considerably greater than the term $\frac{I_{co}}{1-\alpha_n}$ in equation (22) which holds in the active region.

Therefore to ensure that the collector-base junction as well as the emitter-base junction is forward biased we must have the condition that

$$I_c < \frac{\alpha_n}{1-\alpha_n} I_b + \frac{I_{co}}{1-\alpha_n} \quad \ldots \quad (34)$$

or alternatively

$$I_b > \frac{1-\alpha_n}{\alpha_n} I_c - \frac{I_{co}}{\alpha_n} \quad \ldots \quad (35)$$

From this we see that the controlled current in the collector circuit is somewhat less than $\frac{\alpha_n}{1-\alpha_n}$ times the controlling current in the base circuit. How much less will depend on the value of the effective series resistance desired in the closed condition of the switch.

2.1.2 *Inverted Operation*

The analysis considered so far has dealt with the case of a transistor in the common emitter connection acting as a switch, with the load in the collector circuit, driven on and off by a constant current source in the base, as shown in Fig. 6. Thus during the active regime, when the switch is either opening or closing, the emitter-base junction is forward biased

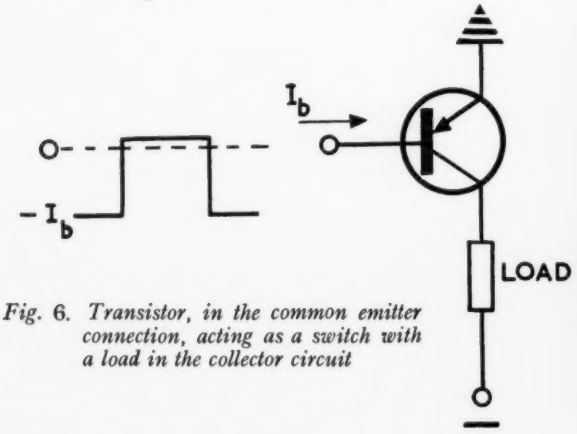
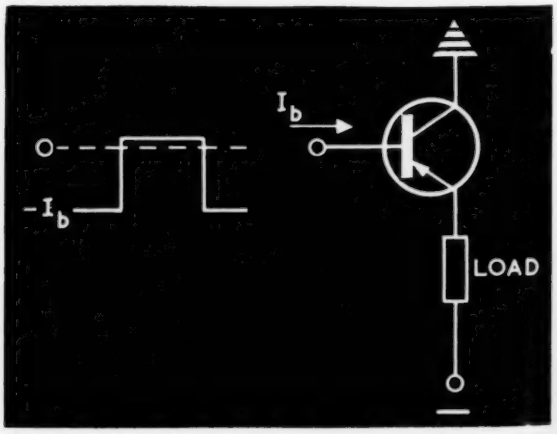


Fig. 6. Transistor, in the common emitter connection, acting as a switch with a load in the collector circuit

Fig. 7. Emitter behaving as a collector, and the collector behaving as an emitter



and the collector-base junction is reverse biased. It is possible, however, to operate an alloy junction transistor with forward bias on the collector-base junction and reverse bias on the emitter-base junction so that the emitter now behaves as a collector and the collector as an emitter as shown in Fig. 7. This results in an appreciable difference in the behaviour of the switch in all three regions of operation. (Fig. 8.)

2.1.2.1 *Off State*

The conditions are as stated in Section 2.1.1.1 but we are now interested in the current which flows in the emitter circuit when both junctions are reverse biased. This is obtained from equation (15) viz:

$$I_{e(sim)} = \frac{I_{eo}}{1-\alpha_n\alpha_i}(1-\alpha_n)$$

2.1.2.2 *Active State*

The condition which now applies is that the emitter-base junction is *reverse* biased and the collector-base junction is *forward* biased. This condition is obtained if $V_{cb'}$ is positive, and $V_{eb'}$ is negative and both are large compared with $\frac{kT}{q}$.

Equations (6) and (7) then reduce to

$$I_e = I_{co} - \alpha_i I_e \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (36)$$

which in terms of I_e and I_b by substitution from (21) becomes

$$I_e = \frac{\alpha_i}{1-\alpha_i} I_b + \frac{I_{eo}}{1-\alpha_i} \quad \ldots\ldots\ldots\ldots\ldots \quad (37)$$

This equation is seen to be identical in form to (22) but the significance lies in the difference in the magnitudes of the terms.

2.1.2.3 *On State*

The conditions are as stated in Section 2.1.1.3 so that the same analysis applies except that we are now interested in the voltage drop between emitter and collector when $I_e = 0$ and not when $I_c = 0$.

We can thus rewrite (27) in the following form

$$V_{ce} = V_{cb'} - V_{eb'} = \frac{kT}{q} \log_e \frac{I_c + \alpha_n I_e}{I_e + \alpha_i I_c} \cdot \frac{\alpha_i}{\alpha_n} \quad \ldots \quad (38)$$

We thus have

$$V_{ce(I_e = 0)} = \frac{kT}{q} \log_e \frac{1}{\alpha_n} \quad \ldots\ldots\ldots\ldots \quad (39)$$

Similarly to obtain the value of the effective series resistance the expression for V_{ce} must now be differentiated with respect to I_e with I_b held constant.

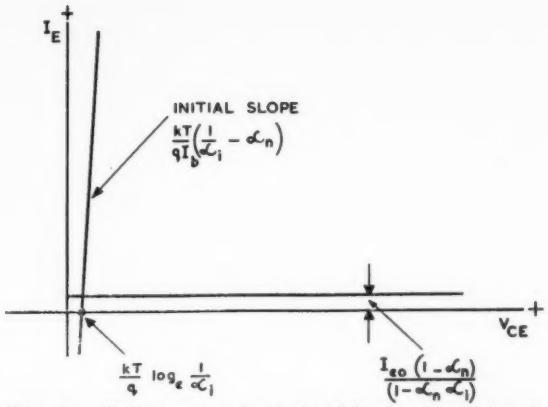


Fig. 8. Voltage-current relationship for transistor in inverted condition

Expressing (38) in terms of I_e and I_b with the help of (21), we have

$$V_{ce} = \frac{kT}{q} \log_e - \frac{I_e(1-\alpha_n) + I_b \alpha_i}{I_e\,(1-\alpha_i)} \cdot \frac{\alpha_i}{\alpha_n} \quad \ldots\ldots \quad (40)$$

Hence

$$\left(\frac{\partial V_{ce}}{\partial I_e}\right)_{\substack{I_b = \text{const.} \\ I_e = 0}} = \frac{kT}{qI_b} \cdot \left(\frac{1}{\alpha_i} - \alpha_n\right) \quad \ldots\ldots\ldots \quad (41)$$

Here again the form of (41) is very similar to that of (31) but the significance lies in the difference in magnitude of the two terms.

2.1.2.4 *Summary of Inverted Operation Behaviour*

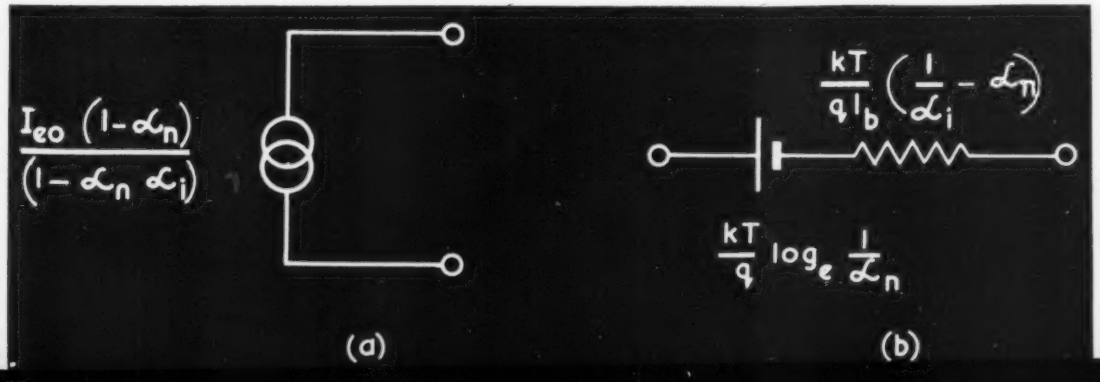
Thus when a transistor in the inverted condition (emitter behaving as a collector and the collector behaving as an emitter) is used as a switch the theoretical analysis predicts the following behaviour:

When the switch is open, a saturation current $\frac{I_{eo}(1-\alpha_n)}{1-\alpha_n\alpha_i}$ will flow across the "contacts" as shown in Fig. 9(a).

When the switch is closed, the e.m.f. of the equivalent battery is $\frac{kT}{q} \log \frac{1}{\alpha_n}$ and the value of the effective series resistance is $\frac{kT}{qI_b}\left(\frac{1}{\alpha_i} - \alpha_n\right)$ as shown in Fig. 9(b).

Equation (31) shows that the current which can be

Fig. 9. Transistor in inverted condition (*a*) *Switch open* (*b*) *Switch closed*



controlled in the emitter circuit is approximately $\frac{\alpha_i}{1-\alpha_i}$ times the controlling current in the base circuit. However as in Section 2.1.1.4, to ensure that both junctions are forward biased in the closed condition of the switch we must have

$$I_e < \frac{\alpha_i}{1-\alpha_i} I_b + \frac{I_{eo}}{1-\alpha_i} \quad \ldots\ldots\ldots\ldots\ldots (42)$$

2.2 *Comparison Between Normal and Inverted Operation*

We can now make a comparison between the behaviour of a transistor in the common emitter connection as a switch when the transistor is in (a) its normal condition, i.e. emitter acting as an emitter and collector as a collector, and (b) its inverted condition, i.e. emitter acting as a collector and collector as an emitter.

The following table summarises the results obtained from the above theoretical analysis:

TABLE I

	Normal	Inverted
Open switch—current across "contacts"	$\frac{I_{co}(1-\alpha_i)}{1-\alpha_n\alpha_i}$	$\frac{I_{eo}(1-\alpha_n)}{1-\alpha_n\alpha_i}$
Closed switch—equivalent battery voltage	$\frac{kT}{q}\log_e\frac{1}{\alpha_i}$	$\frac{kT}{q}\log_e\frac{1}{\alpha_n}$
—effective series resistance	$\frac{kT}{qI_b}\left(\frac{1}{\alpha_n}-\alpha_i\right)$	$\frac{kT}{qI_b}\left(\frac{1}{\alpha_i}-\alpha_n\right)$
Maximum ratio of controlled to controlling current	$\frac{\alpha_n}{1-\alpha_n}$	$\frac{\alpha_i}{1-\alpha_i}$

In order to appreciate the practical significance of these results it is necessary to have a knowledge of the magnitudes of α_n and α_i. For an unsymmetrical alloy junction transistor a typical value for α_n would be 0·98 whereas a typical value for α_i would be 0·7.

Insertion of these values in the above table then gives

	Normal	Inverted
Open switch—current across "contacts"	$I_{co} \times \frac{0{\cdot}3}{0{\cdot}314}$	$I_{eo} \times \frac{0{\cdot}02}{0{\cdot}314}$
Closed switch—equivalent battery voltage	9 mV	0·75 mV
—effective series resistance	8 ohms	11·25 ohms
Maximum ratio (I_b = 1 mA) controlled to controlling current	49	2·3

It can therefore be seen that provided I_{eo} is of the same order as I_{co}, the current across the open switch is about an order of magnitude lower when the transistor is operated in the inverted mode. Likewise the voltage drop across the closed switch is about an order of magnitudes lower for the inverted mode.

The effective resistance in series with the closed switch is somewhat greater for the inverted mode of operation.

However, for a given base current, the current which can be controlled is markedly different for the two modes of operation. As has been shown in equations (22) and (37), for a base current I_b the maximum current which can be controlled is

$\frac{\alpha_n}{1-\alpha_n} I_b$ for the normal mode of operation

$\frac{\alpha_i}{1-\alpha_i} I_b$ for the inverted mode of operation.

Using the values 0·98 for α_n and 0·7 for α_i the maximum controlled current in the two cases becomes

$49 \times I_b$ for the normal mode

$2{\cdot}3 \times I_b$ for the inverted mode.

Thus, although a transistor used in the inverted mode approximates much more closely to the ideal switch characteristic both in the open and closed conditions (the latter especially at low currents), this is achieved at the expense of a large increase which is required in the controlling current. In fact in this mode the controlling current must be made nearly equal to the controlled current.

2.3 *Symmetrical Transistors*

Some mention should be made of the use of symmetrical transistors as switches[3]. For a symmetrical transistor in which the emitter and collector areas are approximately equal we may assume that $\alpha_n \doteq \alpha_i$. As might be expected, therefore, the terms normal and inverted modes have no significance when applied to a symmetrical transistor as a switch, the theoretical expressions given in Table I being identical for $\alpha_n = \alpha_i$ if we also assume that $I_{co} = I_{eo}$. The magnitudes of these terms must still be considered, however, as there are some significant differences between the behaviour of a symmetrical transistor as a switch and an unsymmetrical transistor used either in the normal or the inverted mode. If we assume a value for α_n and α_i of 0·98 then the following values are obtained:

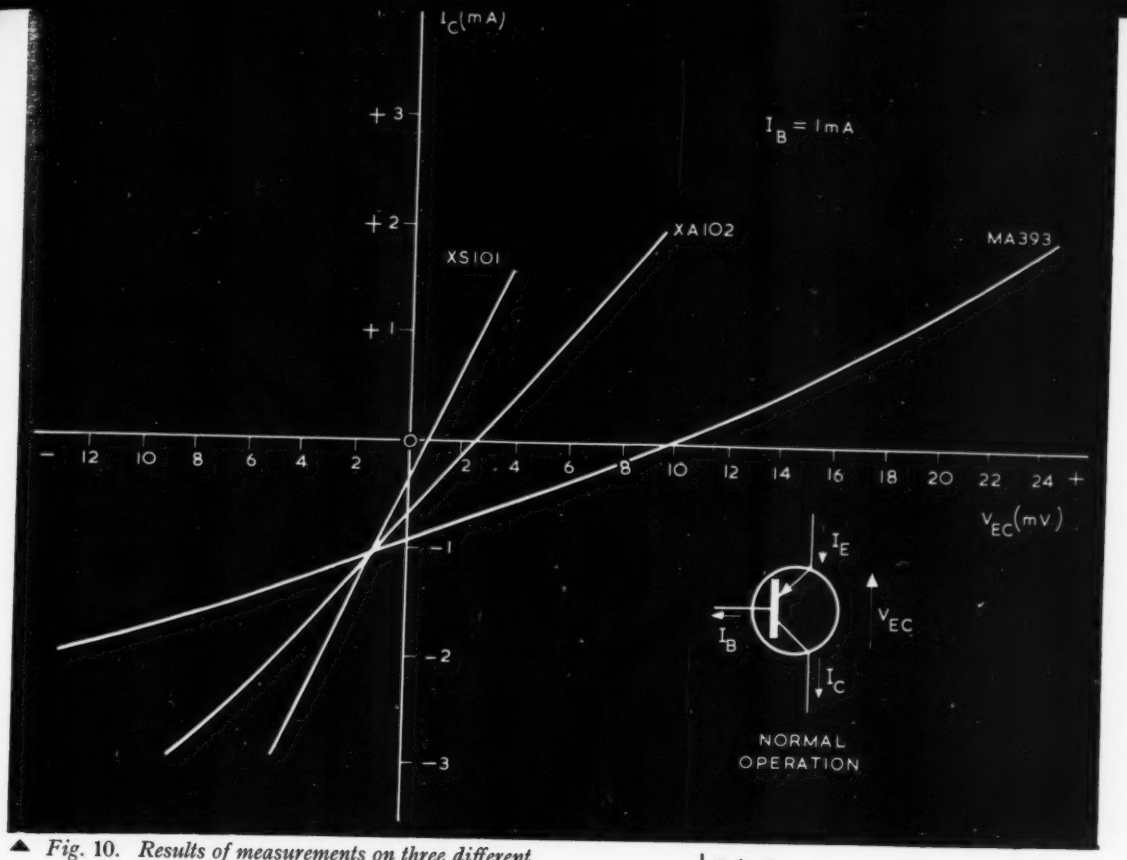
Open switch—current across "contacts"	$I_{co} \times \frac{0{\cdot}02}{0{\cdot}314}$
Closed switch—equivalent battery voltage	0·75 mV
—effective series resistance	1 ohm
Maximum ratio of controlled to controlling current	49

From the above table it can be seen that the symmetrical transistor possesses the most desirable properties as a switch, low leakage current in the open condition, low equivalent battery voltage and low series resistance in the closed condition, and a high controlled to controlling current ratio.

2.4 *Measurements*

Table II and Figs. 10 and 11 give some results of measurements made on three different types of transistors. When comparing the results obtained from measurement with those from calculation the following points should be borne in mind:

The bulk resistance of the semiconductor material will introduce a resistance in series with the connections



▲ *Fig.* 10. *Results of measurements on three different types of transistors, in normal operation*

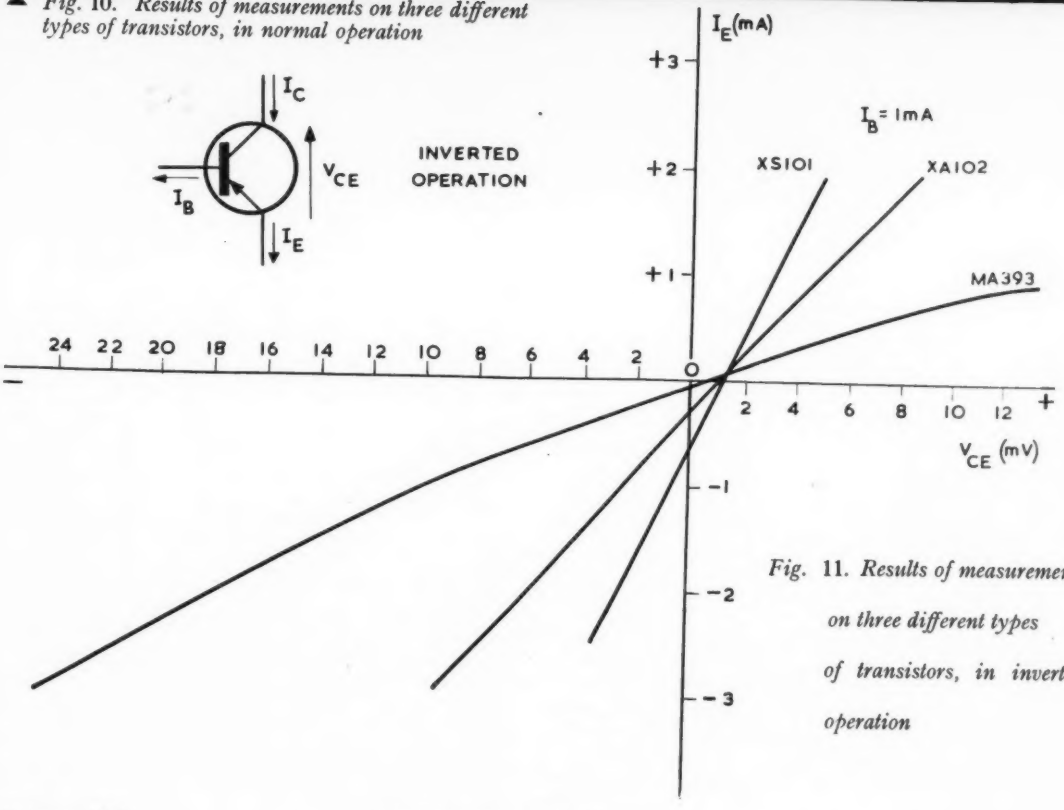


Fig. 11. *Results of measurements on three different types of transistors, in inverted operation*

TABLE II

			V_{EC}(mV) with $I_C = 0$		V_{CE}(mV) with $I_E = 0$		$\frac{\partial V_{CE}}{\partial I_C}$ ohms. with $I_C = 0$	
	β_n	β_i	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.
XS101	43·5	62·8	0·8	0·4	1·1	0·6	1·8	1·0
XA102	31·5	14·8	2·4	1·8	1·0	0·8	3·4	2·3
MA393	250	5·3	10	4·5	0·5	0·1	10·0	5·0

to the active region of the transistor and no allowance has been made for this in the theoretical expressions for the emitter and collector currents.

Again in the theoretical expressions the two proportional factors α_n and α_i are assumed to remain constant over the whole range of working voltages and currents. This is of course not true and to obtain theoretical results which are reasonably close to the experimental ones, both α_n and α_i should be determined in the region of interest. As will be seen from the table it was found more convenient to measure β_n and β_i rather than α_n and α_i.

The calculated values for both the voltage drop between collector and emitter and the slope resistance are sufficiently close to the measured ones for the behaviour of the three types to be clearly separated. Much closer agreement can be obtained if an estimate is made of the value of the effective resistance in series with the connections due to the resistance of the semiconductor material. In the case of the micro-alloy transistor type MA393 for example, this amounts to approximately 5 ohms.

References

1. J. J. Ebers and J. L. Moll. "Large Signal Behaviour of Junction Transistors." *Proc. I.R.E.*, **42**, Dec., 1954, pp. 1761-72.
2. G. B. B. Chaplin and A. R. Owens. "Some Transistor Input Stages for High-gain D.C. Amplifiers." *Proc. I.E.E.*, **105B**, 1958, pp. 249-57. (I.E.E. Paper No. 2382M, May, 1958).
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(Part 2 will be published next month.)

Calibration of Inductive Voltage Dividers

Summary: The National Bureau of Standards has recently improved its services for the calibration of inductive voltage dividers. With the aid of special capacitance bridges, extremely accurate calibrations are given for this type of device. Inductive voltage dividers can be calibrated at NBS by comparison with the standard. The comparison method is simple and should find widespread application in many other standardising laboratories.

ACCURATE calibrations of inductive voltage dividers are now available from the National Bureau of Standards in Washington, D.C., and Boulder, Colorado. This service, performed for standards laboratories, industrial concerns, and various research groups, plays an important part in the Bureau's basic electrical measurements programme. By maintaining standards against which electrical devices can be calibrated, the Bureau insures a common, consistent basis for electrical measurements in this country.

Inductive voltage dividers in general are tapped windings on toroidal cores which have very high magnetic permeability. Decade inductive dividers are useful as ratio arms of precision bridges, as voltage dividers for the accurate division of voltages, and as standards for calibrating other dividers by a comparison method.

The initial establishment of voltage ratio over a wide range requires complex procedures and specially fabricated equipment. A comparison method is then used at the Bureau to provide a simple and efficient calibration service with negligible degradation of accuracy. Close attention is given to sources of error that formerly would not have been detected. The precision of this method has been verified by T. L. Zapf and R. V. Lisle of the Bureau's Boulder Laboratories. The method is a modification of a comparison technique investigated earlier at the Bureau's Washington laboratories. The comparison method described requires very little equipment and should find wide-spread application in many laboratories.

A calibration that is adequate for most measurement purposes consists of a determination of the correction to the nominal output-to-input voltage ratio for each step setting of the highest three decades at a specified input voltage and frequency (commercially available inductive voltage dividers usually have 4 to 7 decades). This procedure provides about 30 discrete ratio settings for which the true voltage ratio can be computed. For best accuracy only one of the highest decades should be set at a step other than zero at any one time because, in general, the corrections for the separate decades cannot be simply combined. However, the reading of the lowest decades usually does not significantly affect the correction to the reading of the highest decades. Thus, if the complete reading of the inductive voltage divider is defined as the sum of the reading of the

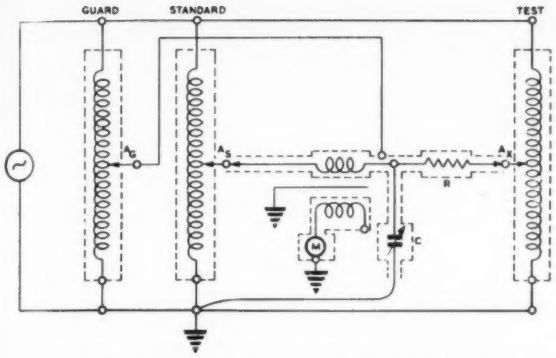


Fig. 1. This diagram shows the bridge circuit used by the National Bureau of Standards in calibrating inductive voltage dividers by comparison with a standard. The input terminals of the test and standard dividers are connected with heavy, short leads to reduce voltage drops between dividers.

highest decades plus the reading of the lowest decades, the true ratio at this setting will be this sum plus the correction to the highest decades.

A guard around the detector input circuit prevents current leakage through stray impedance which would otherwise seriously degrade the accuracy of the measurement. The guard is connected to a divider set at the same reading as the standard so that the shield is nearly at the same potential as the output of the standard and test dividers.

If the connections to ground are made as shown in Fig. 1, the stray capacitance from the shield to ground is predominantly from the shield surrounding the input winding of the detector transformer and the case of the variable capacitor. Voltage across this capacitance must not produce a current in the shield of the coaxial cable leading to the output terminals of the dividers, because this current would induce a voltage in the inner conductor that could produce a noticeable error; instead, the current must be conducted directly to the guard divider. Therefore, the shielded connector between the detector transformer and the capacitor is short, and the output of the guard divider is connected at this point. Care must be exercised not to touch the shield circuit because of the shock hazard, and it is advisable to insulate the coaxial cable and connectors to avoid accidental short circuits. Fuses in the output of the power supply are helpful in preventing damage from short circuits.

The possibility of error arising from the difference in voltage between the shield and ground can be avoided if the guard circuit is grounded at the output of the guard divider rather than at one end of the divider. With this connection it may be necessary to use an isolation transformer between the oscillator and the measurement circuit. The cases of the dividers will not be at ground potential and care should be taken to avoid shocks and short circuits.

The resistance and capacitance produce a component of voltage approximately in quadrature with the voltage applied to the inductive divider. This quadrature voltage can be made to oppose that resulting from the small phase angle difference between the output voltages of the standard and test inductive voltage dividers. As the resistance is much smaller than the capacitive reactance, the predominantly capacitive current produces the desired quadrature voltage across the resistance. By proper choice of resistance the phase angle difference, in microradians, can be made direct reading on the variable air capacitor marked in picofarads. It can be shown that the difference in phase angle between the outputs of the two dividers is approximately equal to ωCR, in radians.

The variable air capacitor chosen should not be large enough to load the inductive voltage dividers appreciably. The effect of this loading can be seen by placing an additional capacitor of equal value across the output terminals of the divider and noting the change in balance conditions of the bridge. An extrapolated correction for loading can easily be applied.

A phase-sensitive detector-amplifier with oscilloscope presentation can be used to good advantage. If the detector responds linearly to small voltage differences, the careful observer can interpolate between the step settings on the smallest decade. If adequate amplification is available in the detector-amplifier, the precision of comparison is limited primarily by the resolution of the standard and test inductive voltage dividers and the ability to interpolate.

A partial verification of the accuracy of the comparison method together with the accuracy of corrections applied to the standard divider can be obtained by reversing the input connections to the test divider, and measuring the complement of its indicated ratio.

Assessment of Surface Texture

The British Standards Institution has brought out a revised Standard B.S. 1134:1961 covering the centre-line-average height method for the assessment of surface texture. This standard was first published in December, 1950.

Changes have been made in the terminology used and the specification incorporates the fullest measure of agreement between America, Britain and Canada as reached at meetings held in Chicago in June, 1960. Information on the root-mean-square method and the peak-to-valley method of assessment are no longer given.

The standard relates to preferred values for the grading of surface texture (centre line average values); standard meter cut-off values to be used in graphical procedure and instrument construction; the graphical determination of CLA values; the instruments and methods to be employed in the quantitative assessment of surface texture; the information to be given in statements relating to surface texture.

General information and guidance on the assessment of surface texture is given in the appendix.

NEW PATENTS

The following extracts have been taken from specifications obtained from the Patent Office, and permission to publish has been given by H.M. Stationery Office. The Official Journal *Patents* can be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2.

Patent No. 844,169. Voltage Measuring Apparatus. *Metropolitan-Vickers Electrical Company Ltd.* (*Inventor: William Percival Baker.*) (*Application No.* 19990/57.)

The invention, relating to high voltage measuring apparatus, is important in high voltage pulse generators such as those for particle accelerators. In such pulse generating equipment the high voltage makes the measurement difficult—because the main voltage pulse of the transformer secondary is followed by a voltage excursion of opposite polarity which the voltage measuring apparatus must reject. This voltage frequently is so high that direct measurement necessitates the use of a potential divider. The design of a resistance potential divider presents difficulties and these cause inaccuracies in measurements. The invention is claimed to provide apparatus which avoids or minimises the difficulties referred to and this is the main object of the patent.

Patent No. 844,849. Electronic Storage and Switching. *National Research Development Corporation.* (*Inventors: Gerald Horace Perry and Eric William Shallow.*) (*Application No.* 8827/56.)

The electronic storage and switching arrangements featured in this invention refer to binary counters. A binary counter is a circuit which for every two successive input stimuli received gives a single output signal. Such counters are often based on the use of a so-called two-state permanent memory—a two-state circuit element which can be driven into one or other of its two states by appropriate input signals and, in the absence of further input signals, remain in that state indefinitely. In spite of this convenient element a certain amount of duplication of circuit elements takes place. It is the object of the invention to provide an improved binary counter in which some economy of circuit elements is obtained.

Patent No. 844,852. Digital Computers. *The Decca Record Co. Ltd.* (*Inventors: D. W. Wesley and B. L. H. Watkin.*) (*Application No.* 14897/56.)

This invention relates to digital computers having a number of reading heads for reading information from separate magnetic storage elements. Any of the reading heads may be connected to a single output circuit—for example, from different tracks on a magnetic storage drum. Due to low output power from a reading head each has to be provided with a separate amplifier; thus a magnetic drum with 64 tracks would require 64 separate amplifiers. The object of the invention is to eliminate the necessity for a separate amplifier for each head.

Patent No. 845,049. Information Recording Media. *Siemens & Halske, Aktiengesellschaft* (*Germany*). (*Application No.* 12409/58.)

The invention relates to media on which information in the form of numbers, letters or other symbols may be manually recorded for subsequent reading by an automatic reading device. Such information may be recorded by making dashes or similar marks on a paper sheet by pen or pencil. These marks can be read photo-electrically or by a reading device which depends on the conductivity of the mark, and converted into a printed digit or letter and/or a standard code of the kind used for automatic processing of data. The present invention consists of a recording medium in an automatic reading unit having light-coloured spaces on a dark-coloured background in which the information is recorded by darkening some of the light-coloured spaces. It is claimed the method described does away with the disadvantage of known manual recording systems which often result in careless marking and the reading devices normally operating with only a small safety margin.

A further invention relating to a Statistical Record Sensing System for reading information which has been recorded on a medium in the manner described above is described in Serial No. 845,050—Application No. 12140/58. It is the object of this invention to provide a reading system which is capable of detecting certain types of error in the marking of the recording medium.

Patent No. 846,029. Minimising Spurious Signals in an Electromagnetic Flowmeter. *The Foxboro Company* (*U.S.A.*). (*Application No.* 27033/57.)

This invention relates to electromagnetic flowmeters and especially to methods of minimising spurious electrical signals in them. Flowmeters which are particularly suitable for many industrial applications include a flowmeter head comprising a metallic pipe section to be coupled into the fluid flow system under measurement, a coil structure for producing an alternating magnetic field transversely through this pipe section and a pair of electrodes in contact with the flowing fluid and positioned in the pipe so as to sense the electrical potential generated by the flowing of the fluid across the magnetic lines of force. This sensed potential is commonly coupled through a pair of lead wires to an amplifier, the output of which controls one or more of a variety of recording or flow controlling devices. In flowmeters already known, the spurious electrical signals produced are small in amplitude but can produce substantial errors in flow measurement. It is therefore an object of this invention to provide an electromagnetic flowmeter that is superior in this respect to such flowmeters.

(*Continued on page* 1115)

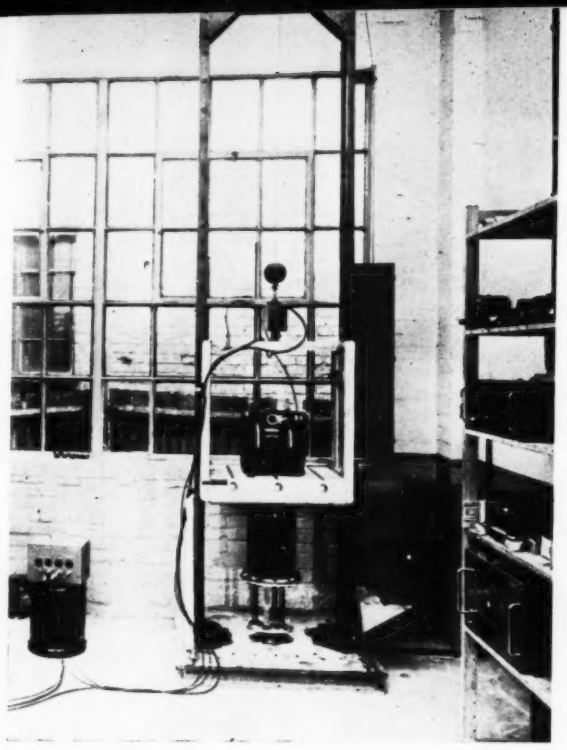


Fig. 1. Pneumatic ram-retarded drop table

By E. A. Falkner, A.M.I.E.D., M.Inst.Pkg.

Director, Hairlok Laboratories Ltd.

The Protective Packaging of Instruments

THE majority of instruments could be loosely described as delicate to a greater or lesser degree, depending upon their design and make-up. The extent to which they may need protective packaging will depend, therefore, upon the degree of delicacy, usually termed fragility factor, together with the severity of hazards likely to be encountered from mishandling or transportation.

The fragility factor expressed as the number of times gravitational force the instrument will sustain without permanent damage is rarely known precisely, but by careful examination an expert could estimate its fragility within fairly close limits.

Evaluating the Fragility Factor

It is desirable, however, where practicable, to take a more scientific course in this evaluation, and subject the instrument to increasing deceleration levels by means of a retarded drop table. Several methods of retarding the table have been developed but the most practicable way is by means of a pneumatic ram (see Fig. 1).

This equipment is capable of producing any deceleration level approximately sinusoidal in shape and of height and duration closely simulating the type of shock it would be subjected to in a well designed pack having a linear resilient form of cushioning.

The method of testing is to clamp a working instrument to the table, in the most vulnerable plane or planes usually found by inspection, and to carry out repeated drop tests with a constantly rising deceleration until failure occurs. This may be either electrical, mechanical, or simply a change of specified characteristics. In this way, the maximum permissible deceleration level can be quickly and accurately established. This type of test is also of value for showing up structural design weaknesses. Designers do not always appreciate that high force levels are built up at relatively low decelerations at the mounting point of components and accessories. A transformer or choke, badly sited on a thin aluminium chassis, will often foul and break adjacent tag strips and components, thus completely ruining the instrument at a deceleration level far below that possible with a chassis perhaps two gauges thicker or with the heavy item positioned, say, in the corner or at the edge of the chassis. A little thought will show that a transformer weighing only 10 lb will exert a thrust of $\frac{1}{2}$ ton at 100*g*, a deceleration most well designed instruments can withstand. A common fallacy is that valves and meters are the most fragile items, but this, in fact, is rarely the case. A piece of equipment which will survive a deceleration higher than an average valve, c.r.t. or meter is uncommon.

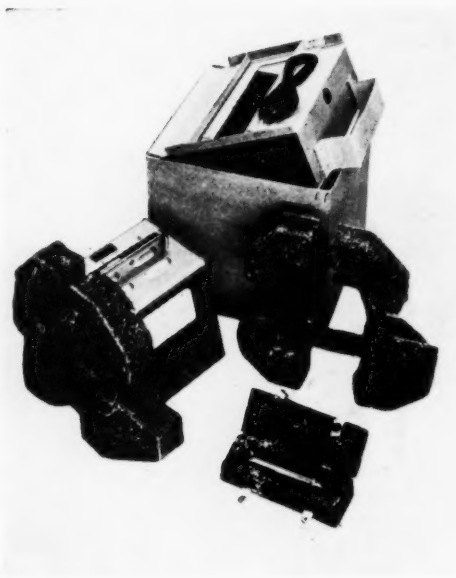
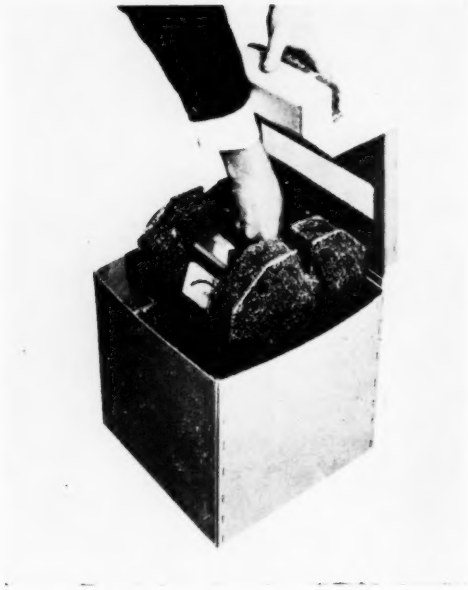


Fig. 2

◀(*a*) (*b*)▶

Commercial packaging for a Parnum gauge unit



Another fragility aspect which must be considered is the effect of vibration, but fortunately this may usually be ignored because of the very low transmissibility of resilient packing material, coupled with their high damping factor and low natural frequency. It is improbable that any damaging resonance would be built up within a well designed package unless one reverted to an obsolescent method of using undamped spring suspensions.

Possible Hazards

Considering now the possible hazards an instrument may encounter at some time during its useful life, and ignoring Services' use wherein some instruments are required to be protected to survive such hazards as near misses from bombs, etc., drops from great heights, severe jolting and bumping in vehicles travelling at speed over rough terrain in the arctic or desert, together with the associated environment of the elements, there are four major factors:

1. Accidental or intentional dropping from any height
2. Vibration, including extensive bumping
3. Crushing, including resistance to internal or external pressure found in freight holds of unpressurised transport aircraft
4. Corrosion.

A packaging specification may call for protection against any one or all these hazards. We will look at two examples, one requiring a simple commercial pack and the other requiring a full standard military pack.

Commercial Packaging

A typical commercial unit submitted for packaging is the Parnum gauge unit. This is a particularly well designed instrument and a fragility test carried out by incrementally increasing the deceleration level from 20*g* from 4 ft 6 in. to 120*g* from 4 ft 6 in. failed to damage the instrument in any plane. After consultation with the designer, it was decided to produce a pack giving 100*g* protection from 4 ft 6 in. This pack is illustrated (Figs. 2(a) and (b)) and it consists essentially of two moulded conforming end caps with just sufficient area and of a density suitable to sustain the peak dynamic impact-load without "bottoming". The unit and end caps are fitted into a tailored carton, and for good measure an accessory and instruction book tray is situated at the top of the carton. This is a good example of a well thought out pack, because on removal of the lid, the instruction book and accessories are immediately to hand and the unit can be lifted out by its own handle.

The prototype pack, complete with a working instrument, was subjected to drop tests on each plane from 4 ft 6 in., the accelerations were recorded, and after the tests the instrument was thoroughly examined and tested and found to be within the designed specification. In recent years, many hundreds of these instruments have been sent both through the post and by public transport in this type of package, with no ill effects.

Military Packaging

The more complex military type of pack is illustrtaed in Fig. 3(a). A master reference gyro, manufactured by Messrs. S. G. Brown Ltd., is the cargo and its fragility was assessed at 35*g*. This gyro unit is located on a mounting frame by means of four anti-vibration units and although the gyro itself will sustain decelerations of up to 35*g*, the anti-vibration mountings would only withstand 10*g*. It was impracticable to pack the gyro and mounting frame separately, because the accuracy of alignment precluded fitting outside the factory. The answer to this problem, therefore, was to design a suitable locking and retaining jig. In this example, the jig is built into the lid of a mild steel

hermetically sealed drum and has integral desiccant bays, desiccant warning indicator, and differential pressure relief valves to permit controlled breathing when transported by air. The jig is so made that it is impossible to insert the gyro in the drum unless it is correctly locked into position.

The complete primary package is then treated as the cargo and packed into rubberised hair conforming girth mouldings and end pads (see Fig. 3(b)), designed to limit the maximum deceleration to 35*g* from drop heights of up to 4 ft 6 in. The outer container consists of a plywood drum, fitted with quick release fasteners and slinging irons.

This type of pack will survive the most stringent military storage and transport requirements in any part of the world and would be fully environmentally tested and a comprehensive test report issued.

It is not within the scope of this article to go into design detail, because this is a highly specialised technique which should be left exclusively to experienced design establishments. However, we will briefly outline how material performance data is obtained and used.

Assessing Materials

Evaluation of materials and presentation of design information is a complex problem and many hundreds of dynamic and static tests are required for the complete analysis.

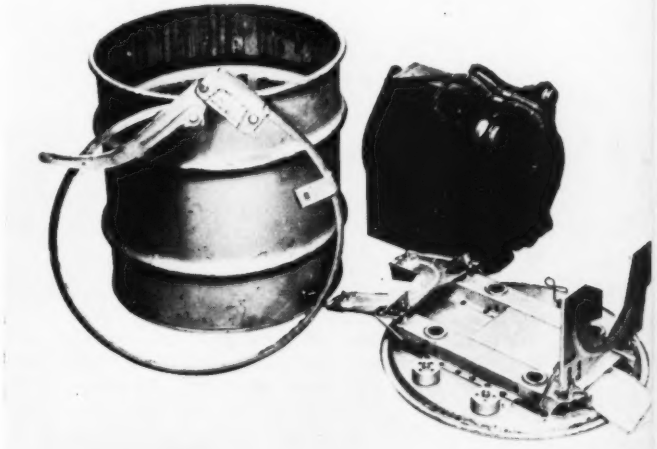
Generally, materials are assessed first by plotting a load deflection curve. A typical one is shown in (Fig. 4). A study of this type of curve will give the designer a guide to its potential. This particular curve shows that the material has a linear spring rate and is reluctant to "bottom" and is, therefore, safe to use down to a deflection of 75%. The following information can, therefore, be extracted from the curve:

1. Its cushion factor, from which minimum deceleration for a given thickness may be calculated
2. Spring rate
3. Loading factor, from which optimum and maximum static and dynamic loadings may be calculated
4. Total energy absorption
5. Apparent efficiency.

This type of information serves as a rough guide to the ability of the material and could be used quite successfully in the absence of more concise information, but because certain factors are assumed, for instance, the dynamic curve will not necessarily be of the same form, it discounts any inertia friction or pneumatic effects and it provides no information on damping, transmissibility and fatigue. It is, therefore, necessary to perform dynamic tests under all environmental conditions, which would include behaviour under adverse conditions of temperature and humidity, wherein test pads would be subjected to many hours' conditioning before test. The test rig shown in Fig. 5 would be used for this assessment. The rig consists of a standard guided softwood case, lined with the material to be tested. A dummy cargo, fitted with accelerometers and the facility of varying the mass by means of screw-on weights, would be used within the case and dropped repeatedly from varying heights, with a varying mass.

The results of tests plotted on a static load/deceleration graph are shown in Fig. 6. From many such graphs obtained with a range of densities and thickness, design curves of cushion factor/density and loading factor/density may be drawn, and they may be used to calculate the correct thickness and density to decelerate any cargo mass as required from any drop height. To enable direct selection, without calculation, further curves are drawn for a range of drop heights, as shown in Fig. 7 and in some instances

Fig. 3. Military packaging for a master reference gyro



▲(*a*) *Primary packing*

(*b*) *Use of rubberised hair*

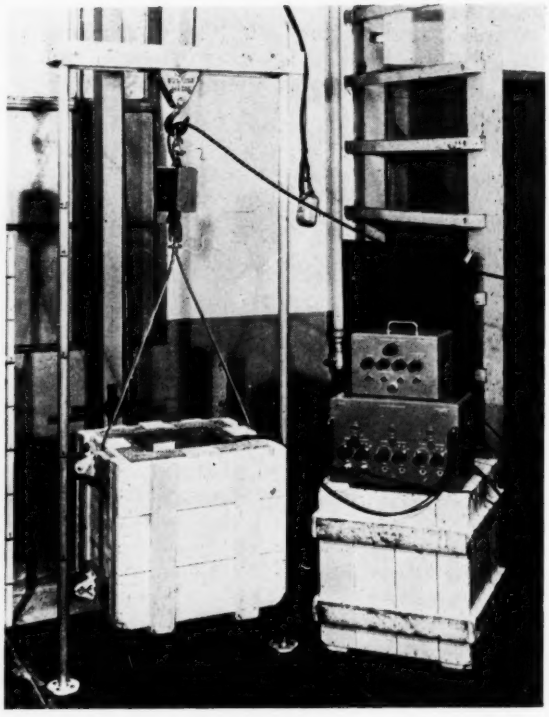
all the information will be displayed on a comprehensive design chart, as illustrated in Fig. 8.

Instruments used to Assess Packaging

Instrument protective packaging has been developed over recent years to a high standard and this is due to a parallel development of recording instruments, which have enabled manufacturers to assess accurately their materials, both statically and dynamically, as well as substantiate the calculated design of prototype packs.

Early acceleration recorders were essentially mechanical systems with distinct limitations, both in respect to frequency response and accuracy, and it was not until the Mullard DDR.100 valve accelerometer became available, and in recent years, the barium titanate transducer, that accurate assessments could be made. The valve, although excellent for recording low frequency fundamental pulses, became obsolescent immediately the barium titanate ceramic became available. This element, when polarised, has a piezo electric effect and this generates a minute voltage proportional to the applied strain over a frequency band of about 2 c/s to many kilocycles.

When this type of accelerometer is used with a simple cathode follower and oscilloscope, excellent results may be obtained if the trace is relatively free of superimposed high frequency transients, but in the case of research and for the evaluation of materials, when many hundreds of drops will be made, it is necessary to record the fundamental quickly and accurately, and for this reason filtered meter display equipment was developed, which will be described in some detail.



▲ *Fig. 5. Test rig for dynamic tests*

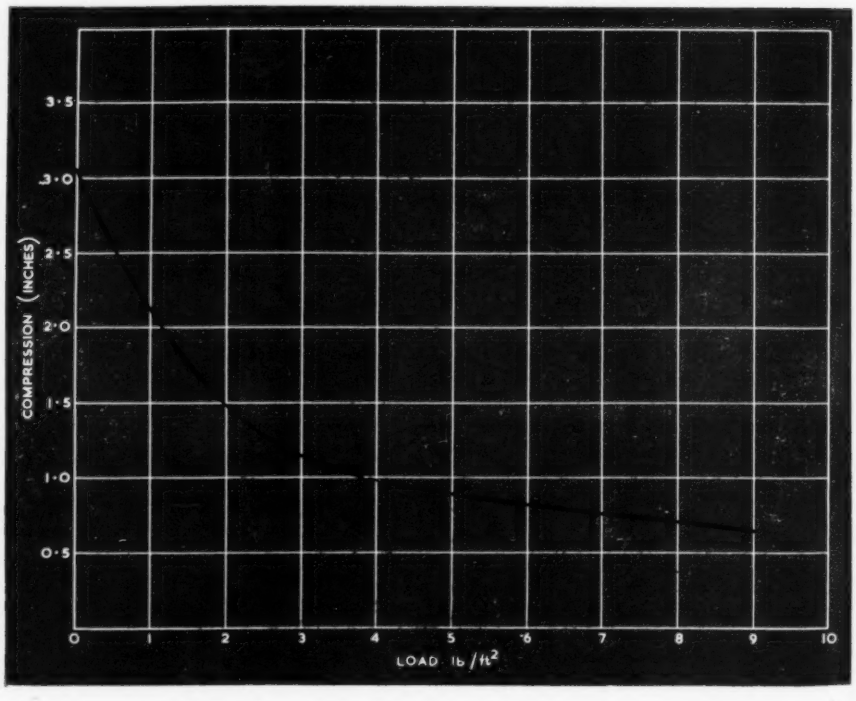


Fig. 4. Typical load/deflection curve
Actual density of material 4·22 *lb/ft³*
Temperature 58°C
Humidity 76%

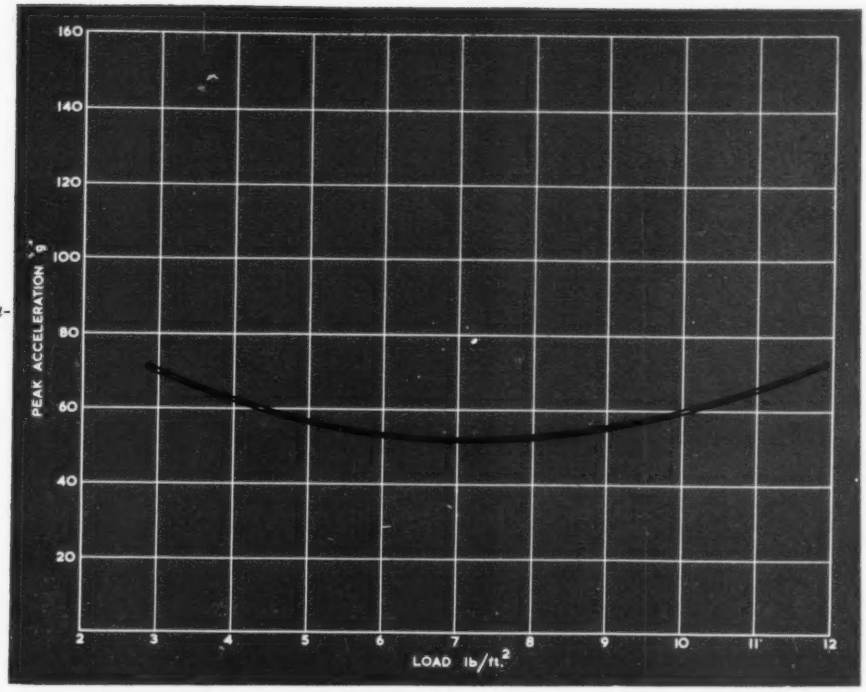


Fig. 6. Static load deceleration graph

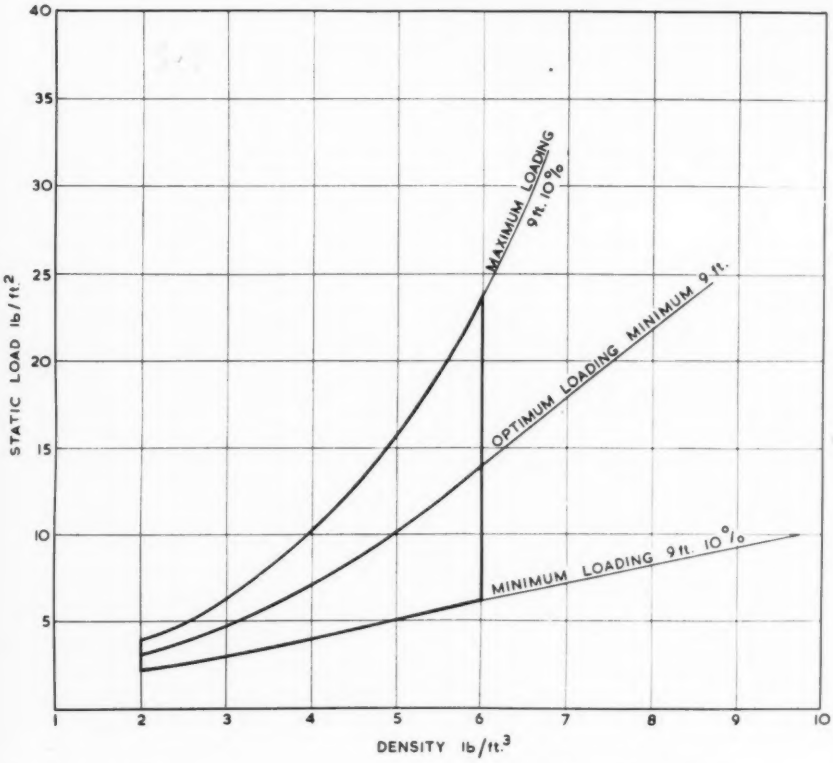
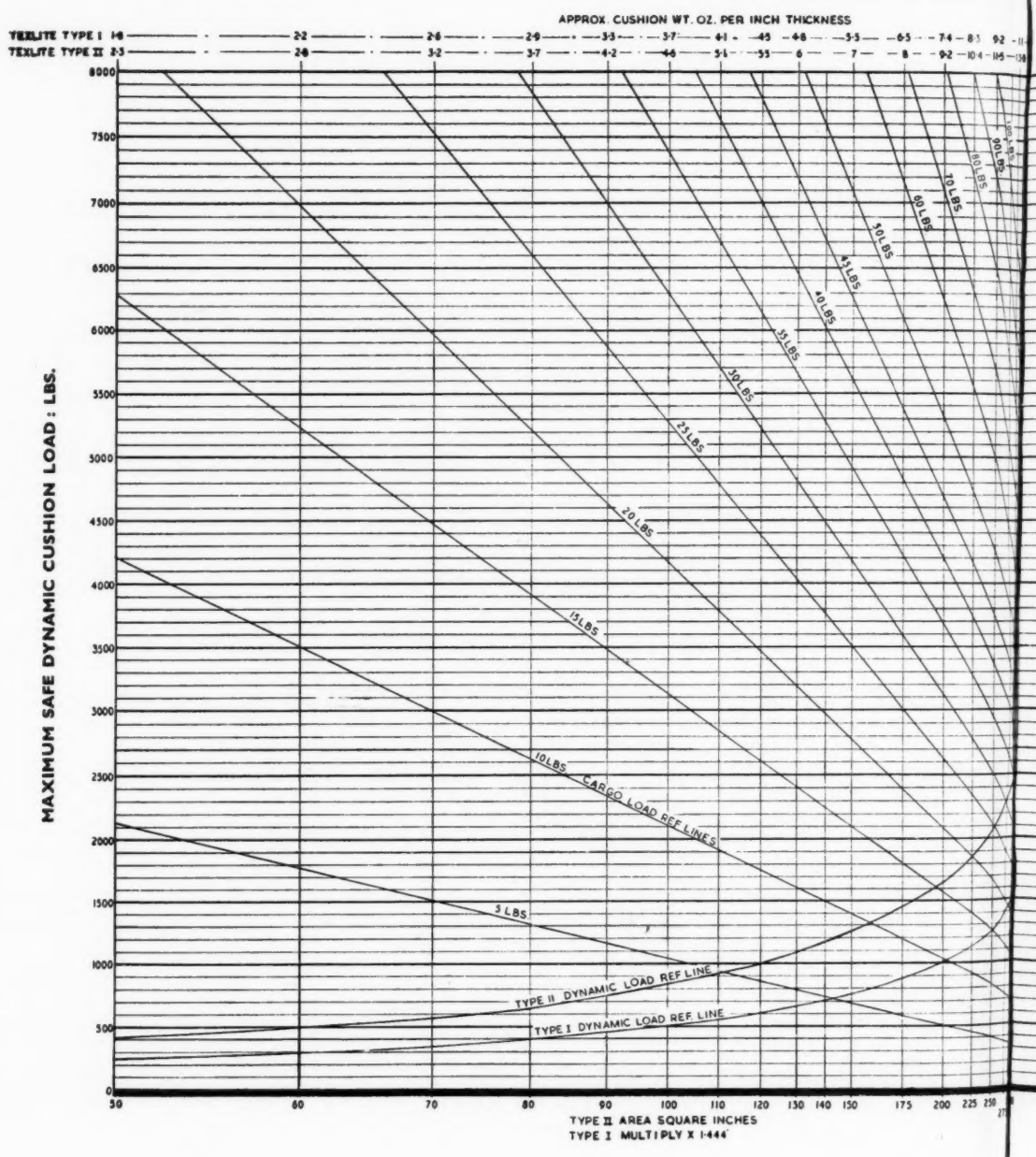


Fig. 7. Loading factor/density curves drawn for a range of drop heights

Fig 8. Comprehensive design chart

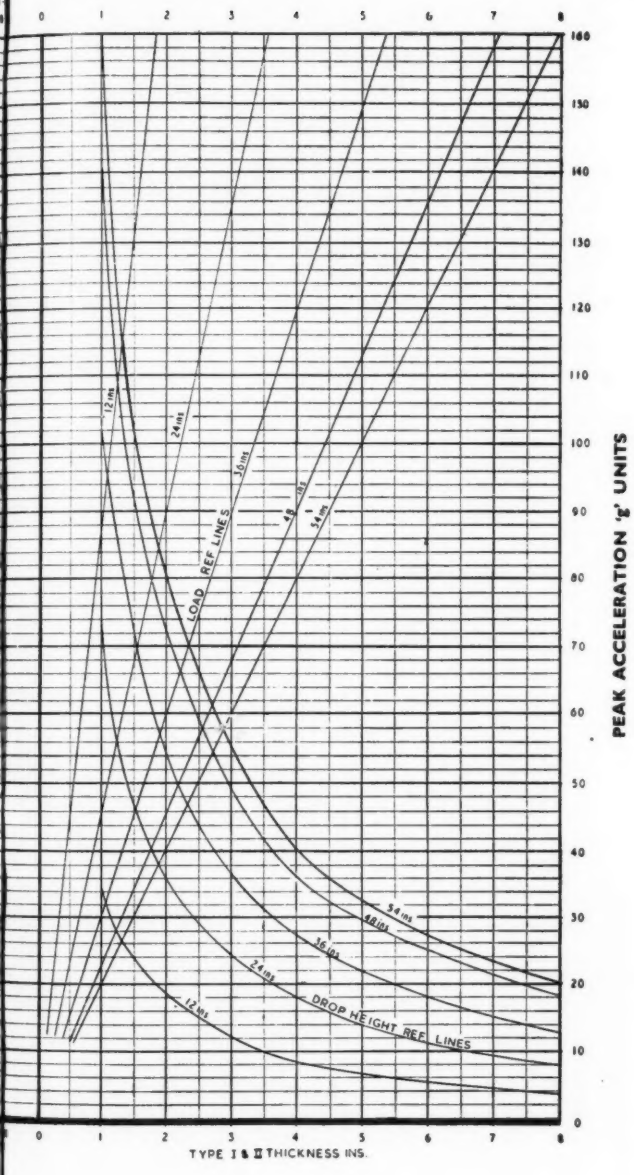


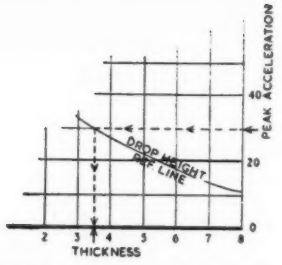
Note

For cargo loads other than those indicated or for inter[illegible]y or divide and area by 10 or 100.

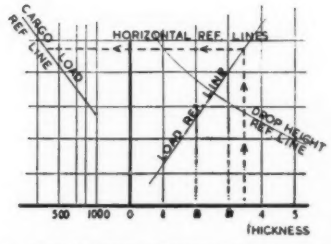
Examples

For a 2lb. cargo load select indicated 20lb. load [illegible] by 10.
For a 700lb. load select indicated 70lb. load and m[illegible] by 10.

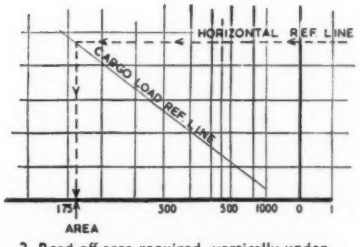




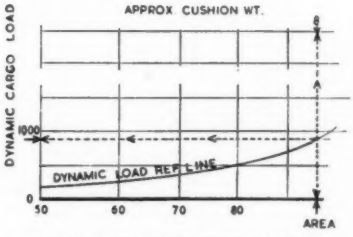
1. Select thickness from known 'g' and drop height. Texlite is made in thicknesses of 1, 1½ & 2 inches and may be plied up if required.



2. Select horizontal reference line coinciding with thickness and load reference line.



3. Read off area required vertically under intersection of horizontal reference line and appropriate cargo load line.



4. If required read off maximum safe dynamic cushion load and weight.

or for inter y or divide both cargo load

201b. load a by 10.
load and m by 10.

5. The method may be reversed.

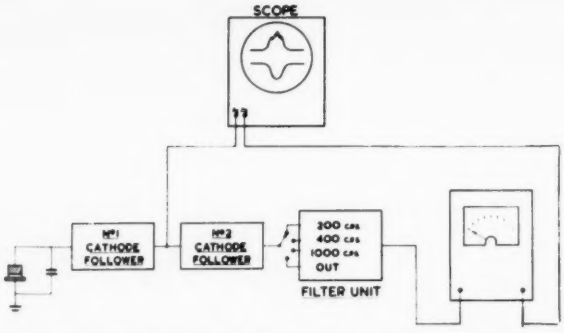


Fig. 9. Block diagram of acceleration recording equipment

A block diagram of the acceleration recording equipment is shown in Fig. 9, with a photograph of the instruments in Fig. 10.

Barium titanate transducers are used universally because they offer the following advantages:

1. Small size and weight
2. Extended acceleration range (up to 1,000*g*)
3. Flat extended frequency response
4. High sensitivity
5. Ease of calibration.

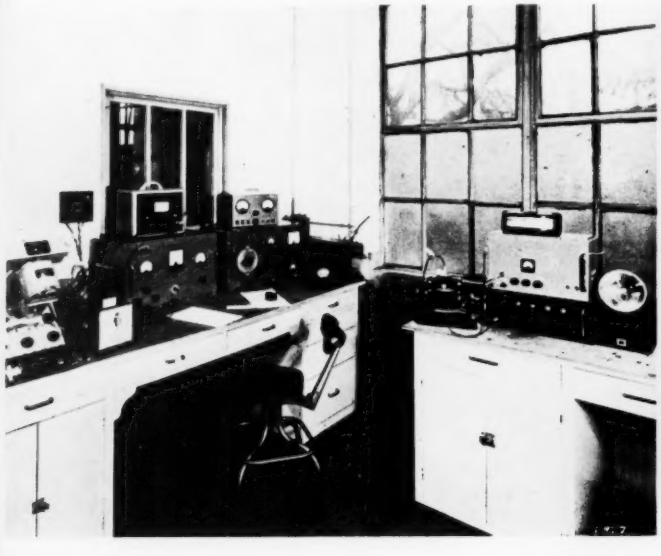
Their only apparent disadvantages are:

1. High impedance
2. Sensitive to humidity.

These disadvantages can easily be overcome, from the high impedance point of view, by the use of a good cathode follower unit and humidity troubles can be obviated by the use of silicone grease applied to high impedance points.

The barium titanate accelerometer is shunted with as high a capacity as the available gain will allow, in our case, 3,000 picofarads. This is included to increase the low frequency response.

Fig. 10. Acceleration recording equipment



The signal is fed into a conventional cathode follower having an input impedance of 300 megohms. With the available capacities, this gives a time constant of one second, thereby preserving the low frequency response down to about 3 c/s. The output from the first cathode follower is fed to the A.1 terminal of a d.c. oscilloscope and also into a second cathode follower, which has its output connected to a selective filter with four positions of 200, 400, or 1,000 c/s and filter out. The filtered output from this second cathode follower drives a d.c. coupled amplifier which has a flat response from d.c. to over 10 kilocycles. The amplifier has a negative feedback circuit ensuring a constant gain of approximately 100. Its output stage feeds both peak reading meter display and the A.2 beam of the oscilloscope.

The meter has two ranges of 0-100*g* and 0-200*g*, and receives its signal via a valve and associated components which are arranged to have a very long time constant by making use of the Miller effect. This long time constant gives a needle dwell on receipt of a signal of about 20 seconds before degeneration occurs.

The complete equipment is capable of measuring on the meter the amplitude of a square pulse of one millisecond duration to an accuracy of 3%.

Use of Filters

With reference to the filters, these are normal two-section low pass resistance capacity types giving 6 decibels attenuation at the selected filter frequency with an ultimate slope of 12 decibels/octave. The attenuation divergence within the normal operating frequency band is ½ decibel (see Fig. 11).

In practice, filters are selected depending on the application or type of dummy cargo being used. If this is the actual item with the usual sub-assemblies it will generate considerable noise over quite a large bandwidth, and for this application the 200 c/s filter would be used and would successfully reduce the noise as shown in the oscillogram (Fig. 12).

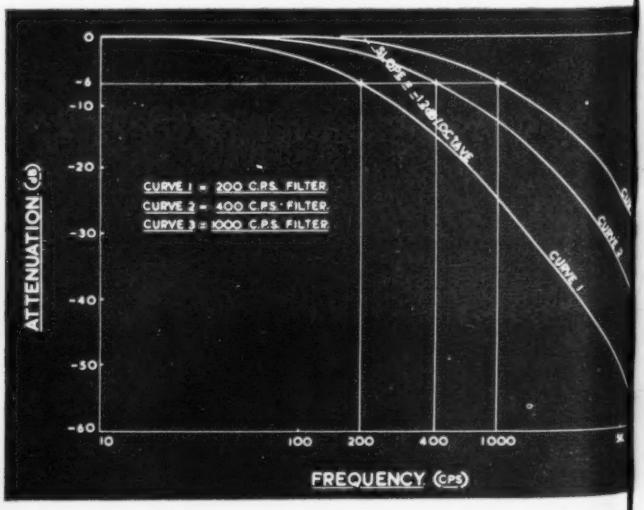


Fig. 11. Filter attenuation curves

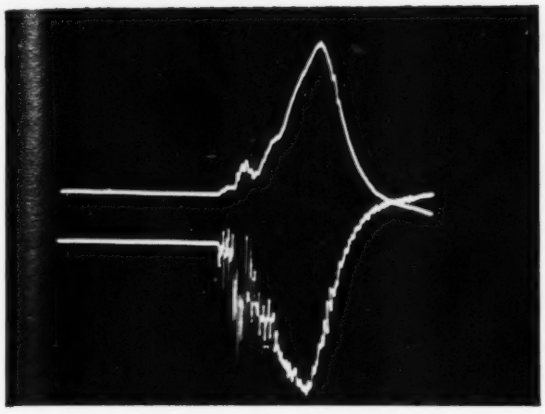


Fig. 12. *Oscillogram showing noise reduction*

The top trace is the A.1 input and the inverted trace the A.2. These oscillograms were taken during a normal drop test and clearly show that the filter has successfully resolved the bottom trace into legibility, and it is obvious that the meter reading would in fact be the correct peak value of the fundamental.

The 400 c/s filter is used on research with ballasted dummies, which usually ring at frequencies over 500 c/s. The 1,000 c/s filter is used only when solid wooden dummy cargoes are available. These dummies are usually substantially non-resonant, but the filter is incorporated as a safety factor. The filter out position is used for comparing the attenuation given by the other filters.

Despite the filtering facilities, care is exercised in the construction of dummies to avoid excitation, and best results are obtained with solid wooden replicas, lead-weighted if necessary.

Calibration of Equipment

The equipment is calibrated by vibrating the accelerometer with a standard oscillator and power amplifier, at a level and frequency close to the theoretical expected from the pack and with the selected filter in circuit. The calibration is then checked at 50 c/s with a transformed mains supply driving the vibrator.

The oscilloscope is calibrated by photographing the trace and using the peak-to-peak height as a reference level. The meter display is calibrated by simply adjusting the gain of the d.c. amplifier to give the appropriate meter reading. After completion of the drop test or series of drop tests, the equipment is re-calibrated; if this shows a deviation greater than 5%, the tests are repeated.

The meter display equipment forms a most useful and convenient means of obtaining quick and accurate acceleration measurements, as the pulse shapes and cargo excitation can from experience be ascertained and the facility of an unfiltered and a filtered oscilloscope trace, together with an instantaneous meter reading, has a distinct advantage, as the traces may either be photographed or viewed on the long persistence screen. Normally, however, it is only necessary to check that the filtered A.2 trace is free of peaks. The meter reading will then be correct. An important advantage of filtering is that an actual cargo may be used for drop testing. Then, not only is it subjected to the acceleration it may sustain in practice, but it can also be mechanically and electrically tested afterwards as a check on its original fragility assessment.

As a control, a duplicate set of instruments, with similar filters and performance to those already described, is used simultaneously, and it has been found that over long periods both sets of acceleration figures agree very closely. If they do not, investigation is carried out to discover the reason.

(*Continued from page* 1106)

Patent No. 846,426. Tape Motion Control Mechanisms. *National Research Development Corporation.* (*Inventor: Donald Wardell.*) (*Application No.* 13463/58.)

Magnetic tape recording mechanisms controlling the motion of magnetic tape past magnetic heads or for controlling the motion of tape on which information is recorded or read by optical, or electrostatic means, are required to have a rapid response to control signals applied to the electrically operated control valves which form a part of them. In known systems the air control valves fitted tend to be slow in operation and the object of the invention is to overcome this disadvantage and to provide rapid response to control signals to an electrically operated control valve.

Patent No. 846,462. Delayed Tripping Mechanism for Electric Switchgear. *The English Electric Co. Ltd.* (*Inventor: Stanley Beddoe.*) (*Application No.* 937/56.)

The invention relates to the provision of a time delay in the operation of the over-current tripping device of an electric circuit breaker. The principle of the invention lies in restraining the movement of the tripping member from the start of its movement until it has moved a certain distance which is governed and communicated to the tripping member through a coupling member by the position of a cam.

Patent No. 846,524. Heating Control Device. *Robertshaw-Fulton Controls Company* (*U.S.A.*). (*Application No.* 11162/58.)

Temperature-regulating devices for ovens and particularly such an oven in which piezo-electric crystals are maintained at a constant temperature have many applications. The advantage of the inherent frequency stability of such crystals is nullified by a small change in crystal temperature which produces a significant change in the frequency. Crystals used in oscillator circuits must be maintained at a constant temperature in order to retain a constant frequency. Such a close control of temperature is usually achieved by a large system expensive to construct, not easily portable and which cannot be incorporated in a small compact electronic unit. The main object of the invention is to provide a constant temperature device for piezo-electric crystals which overcomes these disadvantages.

A. Computer
B. Output-input control station
C. Coating station
D. First inspection station
E. Terminating station
F. Conveyor control equipment
G. Capping station
H. Helixing station
J. Second inspection station
K. Encapsulating station
L. Leak detector station
M. Marking station
N. Third inspection station
O. Packing station
P. Conveyor control equipment
Q. Cap-lead welding machine
R. Detail of conveyor line

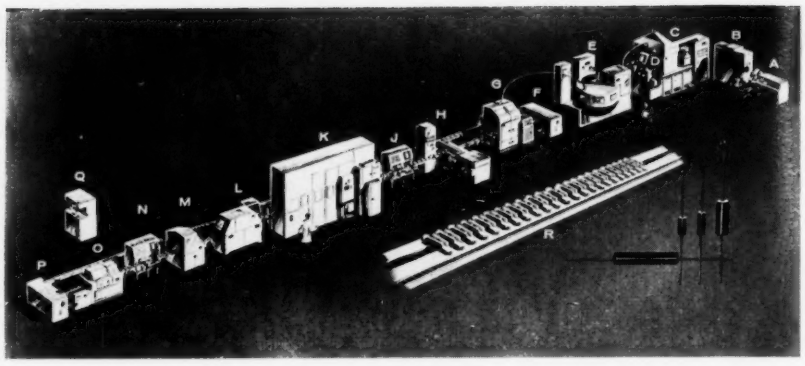


Fig. 1. *Machine stations in the automated production line for manufacturing deposited carbon resistors*

Computer Controlled Production of Carbon Resistors

WESTERN ELECTRIC COMPANY'S new automated production line at their North Carolina Works uses a completely computer controlled process for making deposited carbon resistors.

The line consists of twelve stations, all tied into control by a general purpose computer. (Fig. 1.) Feedback of process data from three key points along the line permits rapid closed-loop operation. The process begins with the deposition of carbon on a ceramic core. Then the core goes successively through inspection, termination, capping, spiralling to value, second inspection, moulding of a protective case, marking, leak inspection, final inspection and packing.

Western Electric decided to develop the automated line when an early survey indicated a considerable increase in total resistor usage, with a definite trend toward the deposited carbon type, and a severe need for greater reliability in resistors, particularly for military usage.

Control Equipment

The heart of the control equipment is a digital computer with a 4096 word magnetic drum memory. Western Electric engineers redesigned it extensively, adding the input and output circuits required for it to control the programming, set up and feedback control of individual machines. Basically, the computer performs in three areas:

1. It programmes production control: a month's requirements can be fed into it at random and arranged according to the four resistor power sizes and an almost infinite number of possible resistance values.

2. Using the methods of statistical quality control, it analyses control data plotted at three critical points in the automated process and applies statistical tests to determine if a trend is developing.

3. It formulates the information to detect any drift away from the accepted manufacturing tolerances. No control action takes place while this analysis indicates normal statistical distribution around a desired nominal. But when a trend away from this condition develops, the computer uses stored data to calculate new set up information for the appropriate station.

In addition to feedback control functions, the computer provides initial set up of wattage size at eight machines and resistance value at six machines.

Time sharing of the input equipment and of portions of the output equipment helps to conserve apparatus in the computer system. The computer output is stored in transistorised registers, wattage size, gas flow and core speed requiring binary registers for each machine. Those machines requiring decimal set up, the helixing machine, the marking machine and the two inspection storage bridges share a single binary coded decimal register.

The input unit is an analogue-to-digital convertor. Although it is time shared between the individual input stations, the 140,000 bit-per-second speed at which it sweeps data into the computer precludes any delay in the computer operation.

Coating

The large batch coating method commonly used in industry proved unsuitable for the automated deposition of carbon film. Effective feedback control required a continuous unit-by-unit feed-through process.

The ceramic core of the resistor enters the coating machine where a control device regulates its speed through the three separate chambers of a horizontal furnace. A horizontal, three-roller support system rotates it *en route* to assure uniformity of coating.

Inert nitrogen gas, continually flushed through the deposition area of each chamber, forms a pressure seal against end-baffles. In the heating areas of each chamber, a temperature of over 2,000°F decomposes methane gas to form carbon on the core. The core is then cooled to room temperature and sent to an inspection station.

Three parameters govern the resistance coating value: the speed of the core through the coating zone, the pyrolysis temperature and the flow of methane gas. The computer controls these parameters through a feedback loop around the furnace. It computes the control information from statistical quality control data stored on the memory drum. Solenoid actuated digital flow valves provide the computer with the precise binary unit response needed to control the gas flow in the coating zone.

First Inspection

The first inspection station forms a feedback loop from the coating furnace through the computer. Here, the coated core goes between four probes using the Kelvin bridge principle. Analogue voltage proportional to resistance is digitised and fed to the computer memory drums where it is stored and sampled against that of the programmed requirements also stored on the drum. The results from this inspection form the basis for feedback control of the furnace. A graph at this station records the test for visual monitoring.

This station also inserts magnetic slugs as instructed by the computer to separate individual lots of resistors when changes of resistance value or of resistor size are called for.

Terminating

The carbon coated core next goes to a terminating machine which sputters a gold contact over each end (Fig. 2). Rotary indexing vacuum chambers are used for this. A few of the 36 stations are used to load and unload parts. The others are used for pump-down and back-filling of argon gas and for the sputtering, as the vacuum chambers advance on their circular track.

The core first goes to a pick-up station to be fitted with a mask, which holds and protects the centre of the core. (Since there are four different sizes of resistors, the computer programmes proper mask sizes.) The mask is loaded on to a vacuum station and covered with a bell jar, which is pumped to a vacuum and then backfilled with argon gas at low pressure. Then the ends of the core protruding from the mask are sputtered with particles from a gold cathode. The sputtering lasts for almost a minute, depositing a layer of gold approximately ten millionths of an inch thick. The gold deposits uniformly because two rollers, actuated by an external magnet, rotate the core inside the mask for maximum exposure.

Capping

A capping machine next attaches leads to the resistor.

The wire leads are first attached to hexagonal caps of gold-plated brass. This is done by an automatic percussion welding machine outside the line. The cap-lead assemblies are then inserted into the capping machine which feeds them into capping chucks. The resistor core, coming from the terminating machine, is loaded on to a turret which holds it in position while the

Fig. 2. Inspecting the computer-controlled terminating machine in the automated production line for manufacturing deposited carbon resistors. The gold cathode in the bottom of the bell jar is used to sputter a layer of gold on the ends of the carbon-coated resistor core.

capping chucks simultaneously press the cap-lead assemblies over both ends. (The machine operates on a demand basis so that the arrival of a carbon-coated core automatically triggers a capping operation.) The capping force is sufficient to weld the gold plating of the cap to the gold on the ends of the core.

The capping machine uses two different capping assembly heads and three different sizes of caps to take care of the four resistor wattage sizes. The computer controls both the switching of the assembly heads and the changing of the cap sizes.

Helixing

The helixing machine cuts a spiralled groove along the carbon film of the core to obtain the desired resistance. A computer-controlled bridge monitors the cutting, which is done by rotating the properly chucked resistor against a diamond-impregnated wheel. The bridge's control servos balance when the desired resistance is reached, disengaging the bridge lathe. During cutting, the bridge also senses any non-linearity indicative of chipping or thin spots in the coating; such cores are automatically rejected. The control circuits also reject any resistor that reaches value before 75% of its length is used, or fails to reach value in its full available length.

The helixing, or spiralling, is done "dry" and continues until final resistor value is reached—an achievement which eliminates the hand-rubbing final adjustment method previously used. The helix lathe bridge is slightly biased to compensate for machine inertia and for resistance change caused by the heat generated in grinding. This data is programmed and stored in the computer memory drum. The computer

also ties into a servo that controls the speed and pitch used for proper spiralling. The three-second spiralling speed, a fraction of that commonly used elsewhere, was accomplished by carefully balancing the rotating mechanism and using a magnetic counter-weight to hold the movable chuck assemblies against the diamond cutting wheel.

Second Inspection

The feedback control and self-correction of the helix lathe bridge is based on a statistical quality control analysis of values inspected at the second inspection station. A Wheatstone bridge, set to the desired nominal resistance value of each resistor lot by the computer, precisely measures the resistance of the resistor. Off-balance voltage is digitised and fed back to the computer, which then computes the desired correction and corrects the helixing machine setting. Defective resistors are automatically rejected. Visual monitoring of values is also provided at this station.

Encapsulating

The resistor next feeds into an encapsulating machine. Here, a pre-cured epoxy shell is fitted over the core, and two partially cured epoxy pellets are inserted over each lead. Held between resilient rubber chucks, the resistor moves through an oven for approximately 15 minutes in a curing temperature of over 300°F. (The resilient chucks prevent escaping trapped air from causing leaks in the finished resistor.) The shell, fully cured, does not melt, and rests on the gold caps of the resistor, retaining an air space along the resistor body to prevent organic contamination of the carbon film. The partially cured pellets on the leads soften, forming an effective seal with the shell. The resistors then pass through cooling water jets which terminate the cure of the epoxy pellets.

Detection circuits within the machine reject any resistors with missing shells or missing pellets.

Leak Detection

Moving along a conveyor from the oven, the resistor is picked up by the holding clip of a leak inspection turret. The holding clip immerses it in a hot water bath containing a wetting agent to prevent surface bubbles from clinging to the resistor body. The heat expands the air inside the capsule, and a series of ten photo-electric cells watch for air bubbles which would indicate a leak.

A special memory device rejects improperly sealed resistors as they leave the tank. The heart of this device is a mechanical memory tab associated with each resistor holding clip. The tab retains the identity of any individual resistor rejected at any one of the leak detectors. The machine can detect leaks as small as 2 10^{-6} cm^3 per second.

Marking

A computer-controlled marking machine now stamps on the wattage, resistance value, production lot number and date on the encapsulated resistor.

The machine uses a modified offset printing technique. Conventional offset printing requires a small type head which reciprocates during the inking cycle of the blanket roll. In this machine, however, the necessity for response to computer control dictated the use of a rather bulky typehead. Therefore, it was decided to mount the blanket roll and inking rolls on a planetary gear arrangement. This permits the type head to remain stationary, and permits the addition of servo drives to make automatic type changing feasible.

Servo drives controlled by the computer can set any one of forty-five different code numbers with over a million and a half permutations of code and resistance value combinations. The automatic controls also provide blanket roll cleaning between code changes and during idle periods which might otherwise cause the ink impressions to dry on the blanket roll.

Third Inspection Station

The final inspection station, a feedback control point, resets the preceding inspection station to compensate for shifts in resistance value caused by the heat of encapsulation.

Packing

Next, the resistor moves on to a packing platform where it is pushed into a bank between two loading jaws. When the bank fills, an anvil pushes the pre-positioned resistors into a Styrofoam block. The block goes down a hopper into a loading magazine.

This machine is also controlled by the computer, which actuates servos to control the platen and anvil stroke settings for each of the four resistor sizes.

Conveyors

Between the first four stations of the automated line, the resistor core is transported by being blown through a plastic tube with gentle air pressure. From the capping machine through the succeeding operations, the resistor moves from machine to machine by a conveyor control system. This system uses individual stainless steel pallets which move along continuously-running conveyor belts.

The pallets transport individual resistors to the machine operating position and receive the resistor after the completion of operation. The conveyors, part of each individual machine, provide an indexing pallet transport mechanism. A rubber-tipped push rod retains the resistor on its tip by means of a vacuum system connected through the rod's hollow core. A suitable cam-actuating mechanism for the push rod is synchronised with the machine operation, loading the resistor into the machine.

Space is allowed between each machine for accumulation of a five minute " bank stock ", and each machine feeds from this storage space on a demand basis. Inventory control is maintained, since each machine shuts off when the storage space is filled.

Cap-lead Welder

An automatic machine outside the line percussion-welds a solder-coated lead to the gold-flashed brass cap used in the capping operation. The weld is made at the joint of the cap and the lead by an extremely short (less than 300 microsecond) arc of high intensity. This machine's output rate is approximately 3,600 parts per hour. It has changeable tooling to accommodate three different cap sizes and two wire sizes. Fail-safe features shut off the machine or reject the part in the event that no cap is fed, a lead is not attached, or a poor weld occurs.

Austenitic Stainless Steel Tubing for Bourdon Elements

By E. S. HUGHES*

THE Bourdon principle of using suitably shaped metal tubing as a pressure sensing element for the measurement and control of pressure has been practised for well over a hundred years, and the many types of materials employed include carbon steels, phosphor bronze, beryllium copper, brass, chromium-molybdenum alloy steel and high-nickel alloys. In recent years, however, there has been an increasing preference towards the use of austenitic stainless steel.

Bourdon tubes have been made in several types of stainless steel by Accles and Pollock Limited, of Oldbury, Birmingham, and trials carried out by instrument manufacturers, but the one found to be most suitable is a low carbon, molybdenum bearing austenitic stainless steel. The chemical composition of this steel is shown in Table 1.

Advantages of Austenitic Stainless Steel

The principal advantage of this steel is that of all the different alloys commonly used for Bourdon applications this analysis offers the best resistance to corrosion. It has excellent mechanical properties for these applications providing the material is in the correctly work-hardened condition, and does not require hardening and tempering heat treatment. The mechanical properties are such that it has been used for pressure gauges up to 80,000 lb/in^2. A further advantage is that it can readily be welded, brazed, or soldered.

As no rust-proofing or hardening and tempering treatments are required, the overall cost of an instrument in which stainless steel Bourdon tubing is used can compare favourably with the use of low-alloy heat treatable steels. Gauge manufacturers, therefore, are able to replace a number of ferrous and non-ferrous metals with one standard material for general applications.

TABLE 1

Austenitic Stainless Steel Bourdon Tubing—Chemical Composition

Element	Analysis %
Carbon	0·08 max.
Manganese	2·00 max.
Silicon	1·00 max.
Sulphur	0·03 max.
Phosphorus	0·04 max.
Chromium	16·0—18·0
Nickel	10·0—14·0
Molybdenum	2·0— 3·0

Raw Material

Tubing for Bourdon applications, be it in stainless steel or other materials, must be clean, smooth and free from material defects. The material must be of the correct analysis, the shape and dimensions closely controlled, and in the case of stainless steel, the degree of cold work applied after its final softening operation carefully determined.

The raw material used by Accles and Pollock for stainless steel Bourdon tubing is in the form of hot finished seamless hollows made by the process of extrusion. The size of the hollows is normally several times larger in diameter and heavier in wall thickness than the size it is intended to finish, so allowing for a considerable amount of cold work to produce the necessary mechanical properties, refined structure, and smooth fine surface finish.

*Accles & Pollock Ltd.

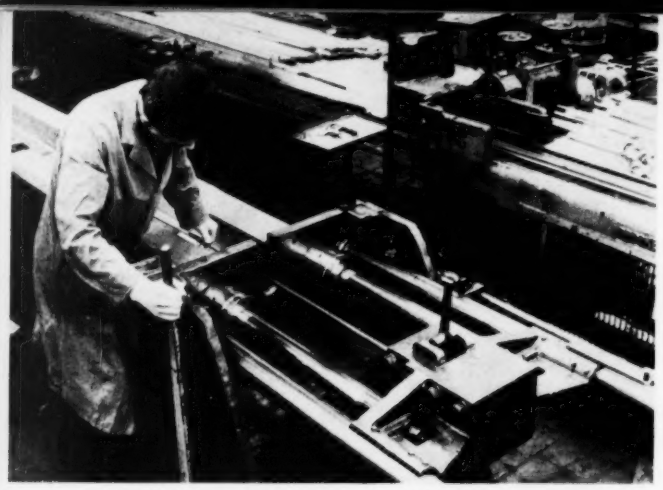


Fig. 1. Cold drawing a stainless steel Bourdon tube showing the tube passing through a section die

The hollows are first machined outside and inside to remove any surface imperfections resulting from the hot-working. At this stage inspection of the bore is carried out by probes giving a magnified view of the internal surface.

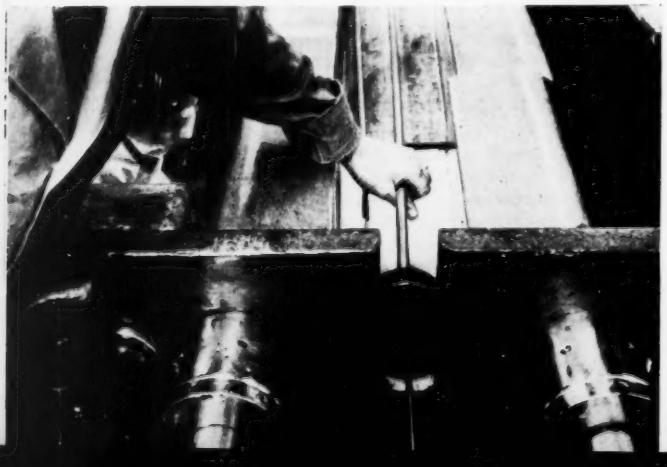
Manufacturing Method

The hollows are reduced to the required size and wall thickness by the process of cold drawing. Several ways of cold reducing or drawing are available, but the one used for Bourdon tube production is plug drawing, a process which ensures adequate cold work on the bore surface as well as the outside surface of the tube.

Basically, the process of plug drawing consists of pulling the tube, cold, through a circular die to reduce its outside diameter, and simultaneously over a plug to support and cold work the bore. The sizes of the die and the plug are so determined as to reduce not only the outside and inside diameters, but also the wall thickness (Fig. 1). Several such drawing operations are required to produce a finished size from hollows. Each draw, or " pass " as it is more commonly termed is calculated in terms of the reduction of the cross-sectional area of the tube, and in the case of stainless Bourdon tubes is generally of the order of 30%.

A conventional chain type drawbench is used for the earlier stages of production. For the final passes a hydraulic drawbench is employed giving a slow start to the draw and ensuring an even flow of metal, fully controlled, to the finished tube (Fig. 2).

Fig. 2. A typical hydraulic drawbench used for cold drawing stainless steel Bourdon tubes



The dies and plugs for the larger sizes are made of hardened and tempered steel, hard chrome-plated and ground. The smaller and finishing passes are all carried out with tungsten carbide tools. Special drawing lubricants, to prevent the " pick-up " of carbon by the stainless steel, are used at all stages.

The bulk of stainless steel Bourdon tubing produced is in the form of elliptical or flat sided oval section shapes. In this case circular tubing of a predetermined size is drawn through a die of the desired configuration and at the same time supporting the bore by a similarly shaped plug.

The work hardening effect of the cold drawing operation necessitates fully softening of the tubes between each draw pass. In the case of stainless steel, this is carried out at a temperature of 1050°C. As rapid cooling is important, fully softening at the earlier stages, i.e. for relatively large diameters and thick walls, is carried out in an open furnace followed by water quenching. To obviate acid pickling sodium hydride reducing is used to remove scale. Tubes under approximately one inch diameter are fully softened in a controlled atmosphere furnace, again to avoid acid pickling.

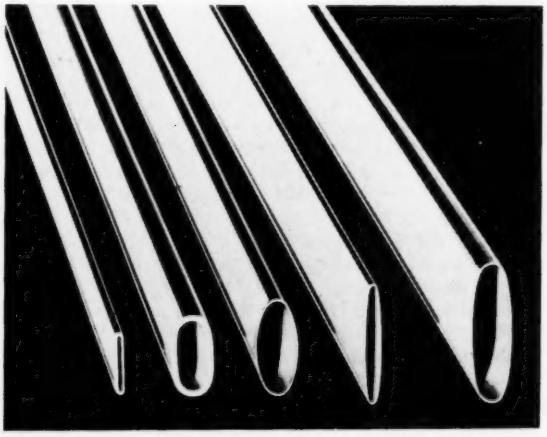


Fig. 3. Some examples of austenitic stainless steel non-circular Bourdon tube sections

At an intermediate stage during the sequence of drawing operations the tubes are again carefully inspected and ground or polished to remove any surface imperfections which may have been exposed by the cold working. This is repeated before the final drawing of circular tubes or, in the case of section shapes, before the shaping passes.

Tube Sizes and Shapes

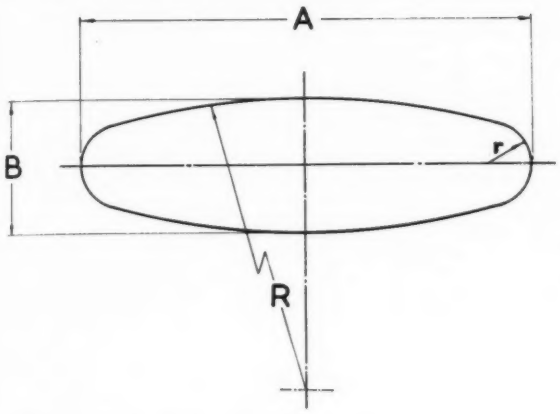
Due to the infinite variety of instrument patterns and designs, Bourdon tubing is available in a wide range of shapes, sizes, and wall thicknesses (Fig. 3).

Round tubing, for example, can be produced by Accles and Pollock in any outside or inside diameter within reasonable limits and any wall thickness in the range 0·005 in. to 0·120 in. As such tubing is only normally used for high pressure instruments requiring screwed joints, the demand is generally for the heavier wall thicknesses.

TABLE 2

Nominal Sections

Internal Dimensions



A in.	B in.	r in.	R in.
0·250	0·100	0·030	0·267
0·375	0·130	0·040	0·488
0·500	0·160	0·050	0·732
0·625	0·190	0·060	0·989
0·750	0·220	0·070	1·253
0·875	0·250	0·080	1·523

Non-circular sections, ellipticals and flat sided ovals, are made in a wide variety of shapes and sizes. These have come into existence over a period of years, largely as a result of the individual requirements of gauge manufacturers, and to meet the many specialised applications of the Bourdon principle.

The British Standard 3127 : 1959 covering Ferrous and Non-Ferrous Bourdon Tubing is an attempt to standardise a range of shapes and wall thicknesses for the more common applications. These are based on six different sections with specified internal dimensions, and a range of wall thicknesses for each section. The nominal sections are set out in Table 2 and nominal thickness in Table 3. Tolerances on the major dimension A, and the minor dimension B, are specified to be within plus or minus 0·005 in. of the nominal dimension.

For the purpose of checking these internal dimensions, the tube axes are measured outside, and from each measurement is deducted twice the actual mean thickness of the tube sample. The minor radius outside, to be checked not less than 6 in. from a cut end, must be not less than r + T and not exceed r + T + 0·020 in., where r is the nominal internal radius and T the nominal thickness. Tolerances on the mean thicknesses are given in Table 4 and eccentricity in Table 5.

It is interesting to note that the nominal sections and thicknesses set out in British Standard 3127:1959 result in no fewer than sixty-one sections, each with different outside dimensions, which, of course, would necessitate that number of sets of finishing tools for the tube manufacturer. These are independent of the range of circular tubes and the many other shapes for which some users still have a preference.

TABLE 3

Nominal Thicknesses

Nominal Size					
¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
Nominal internal dimensions—inches					
0·250 × 0·100	0·375 × 0·130	0·500 × 0·160	0·625 × 0·190	0·750 × 0·220	0·875 × 0·250
Standard thickness—inches					
—	—	0·004	0·004	—	—
—	—	0·006	0·006	0·006	—
0·008	0·008	0·008	0·008	0·008	0·008
0·010	0·010	0·010	0·010	0·010	0·010
0·013	0·013	0·013	0·013	0·013	0·013
0·016	0·016	0·016	0·016	0·016	0·016
0·019	0·019	0·019	0·019	0·019	0·019
0·022	0·022	0·022	0·022	0·022	0·022
0·026	0·026	0·026	0·026	0·026	0·026
—	0·031	0·031	0·031	0·031	0·031
—	—	0·037	0·037	0·037	—
—	—	0·043	0·043	0·043	—
—	—	0·050	0·050	0·050	—

Mechanical Properties

As previously mentioned, stainless steel Bourdon tubing can be supplied in the form of elliptical sections, or as round tubing for the instrument maker to form. The latter is generally the case where, due to high pressure requirements, the fitting into the block is required to be by means of a screwed joint. In such cases one end of the tube is kept circular for threading and the remainder rolled or pressed to the desired shape. On occasions, some instrument makers shape the elliptically drawn sections further. Even tube sections supplied to the shape required for the instrument will be cold worked in forming the spring (Fig. 4).

The extent of the cold work performed by the instrument maker will be additional to the cold work applied to the tube by the tube manufacturer after final softening and will, therefore, affect the temper of the finished spring. To obtain the most satisfactory results there must be good liaison between tube manufacturer and instrument maker. The former can control the mechanical properties of the tubing within fairly narrow limits by adjusting the reduction of area for the final drawing, but he should be given a guide to the mechanical figures required, or the degree of cold work to be carried out by the instrument maker.

The process of cold drawing described earlier produces a work-hardened layer on the inside and outside surfaces of the tube. The final yield strength of the tube is dependent upon the proportion of these two layers to the full wall thickness, resulting from the cold drawing performed after the final fully softening operation. This should be taken into account when circular tubes are machined to reduce their wall thickness prior to forming.

Fig. 4. Pressure switch with a stainless steel Bourdon spring. (By courtesy of K.D.G. Instruments Ltd.)

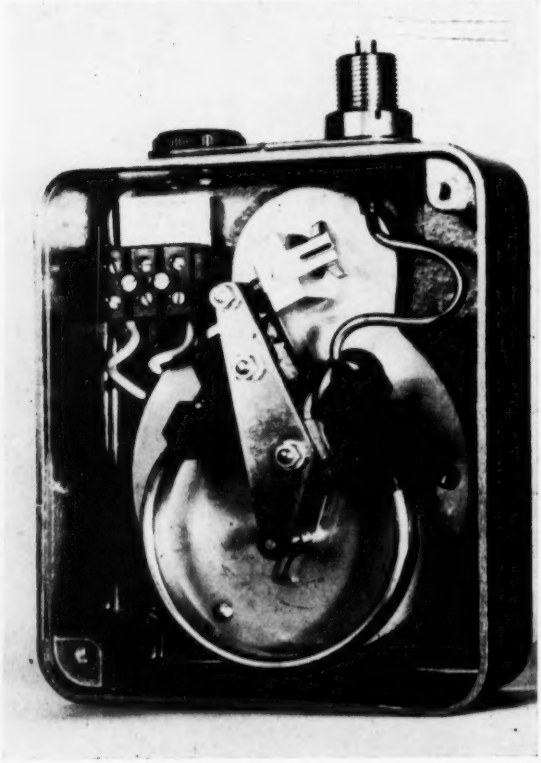


TABLE 4

Tolerances on Mean Thickness

Nominal thickness in.	Maximum difference between mean thickness and nominal thickness in.
0·004 0·006 0·008	0·0010
0·010 0·013 0·016 0·019	0·0015
0·022 0·026 0·031	0·0020
0·037 0·043 0·050	0·0025

The mean thickness to be ascertained by taking the mean of any pair of measurements of the wall thickness at diametrically opposite points.

In the case of thin-wall, low pressure tubes, the two work-hardened layers virtually constitute the full wall thickness of the tube, and sufficient work-hardening takes place if the final fully softening operation is carried out immediately prior to the section drawing. This is referred to as the " as shaped " condition.

A stage in wall thickness is reached at approximately 0·040 in. when the sectioning draw is not sufficient to produce the necessary mechanical properties and additional cold work is necessary. This is produced by two successive draw passes without intermediate softening and is termed " specially work hardened ".

The exact wall thickness for which this special treatment is necessary is difficult to determine exactly, being governed by design factors and coupled with the amount of subsequent manipulation to be carried out by the instrument maker.

From experience Accles and Pollock have established four basic grades of material conditions which meet the normal requirements of gauge manufacturers using austenitic stainless steel Bourdon tubing within the wall thickness range of 0·005 in. to 0·120 in. These are set out below:

Grade 1. Low-pressure circular tubes of thicknesses less than 0·040 in.—" fully softened and descaled " condition.

Grade 2. Low-pressure non-circular section tubes of thicknesses less than 0·040 in.—" as shaped " condition (i.e. the material is fully softened immediately prior to the sectioning operations).

TABLE 5

Tolerances on Eccentricity

Nominal thickness in.	Maximum eccentricity* in.
0·004	0·0005
0·006	0·0005
0·008	0·00075
0·010	0·001
0·013	0·00125
0·016	0·0015
0·019	0·002
0·022	0·00225
0·026	0·0025
0·031	0·003
0·037	0·00375
0·043	0·00425
0·050	0·005

*The difference between the largest and smallest measurements of thickness at points diametrically opposite.

Grade 3. High-pressure circular tubes of 0·040 in. wall thickness or greater—" work-hardened " condition. Yield point, approximately 35 tons per sq. in.

Grade 4. High-pressure non-circular section tubes of 0·040 in. wall thickness or greater—" specially work-hardened " condition. Yield point in excess of 35 tons per sq. in. up to 50 tons per sq. in. depending upon wall thickness and application.

This classification of material conditions, particularly Grades 3 and 4, is intended mainly as a guide. On occasions it is necessary to establish by trial and error the exact degree of work-hardening necessary, especially for tubes in the region of 0·040 in. wall thickness.

In all cases it is advantageous to all concerned for the gauge maker to provide the tube manufacturer with details of the manipulation it is intended to carry out. For example, without this knowledge a circular tube of 0·040 in. wall thickness would be ordinarily supplied in the " work-hardened " condition. If the tube were to be completely flattened, which is sometimes the case, this condition would be too hard and a " fully softened " condition would be necessary.

Manipulation

In order to obtain the final mechanical properties all manipulation of austenitic stainless steel Bourdon tubes must be performed cold.

Where softening is found to be necessary at the tube ends, the correct temperature is 1,050°C followed by rapid cooling. For tubes of 0·040 in. wall thickness or greater, this can be achieved by quenching in water. Air cooling is normally satisfactory for tubes with thinner walls.

When circular tubing is formed into an elliptical shape the volume is, of course, reduced. Generally it is not necessary to fill the tube for this operation, but if so, this fact should not be overlooked.

It is not good practice to " round-up " the ends of non-circular Bourdon tube sections to facilitate threading. Where a screwed joint is considered to be necessary, circular tubing should be used, the end threaded, and the remainder of the tube sectioned. Some gauge makers prefer to use screwed joints for pressures over 1,000 lb/in² while others use non-circular section tubes and welded joints up to 30,000 lb/in².

Methods of Joining

Austenitic stainless steel Bourdon tubes can readily be welded, brazed or soldered to the block and end pieces. The method commonly accepted as being the most satisfactory is argon-arc welding. The amount of tube heated should obviously be kept to a minimum. For this reason, heat shunts are sometimes used to minimise the heating effect along the tube during welding.

Ageing Treatment

It is an advantage, before calibrating the instrument, to pulsate the assembled Bourdon element for a short period to allow the internal stresses of the material to be dissipated. This can be assisted by an ageing heat-treatment at 250° to 300°C for two to three hours, preferably after final assembly and welding. Ageing up to four hours is sometimes carried out, particularly for high-pressure applications, but exact temperatures and times are dependent upon pressure ranges and tube thicknesses, and can only be determined by trials.

After ageing treatment the Bourdon element should be cleaned and passivated by a controlled immersion in a solution containing 20 per cent nitric and 5 per cent hydrochloric acids.

★ ★ ★

Bibliography of Temperature Measurement, January, 1953, to June, 1960. *By Carl Halpern and Robert J. Moffat, National Bureau of Standards Monograph* 27, *issued* 6*th April*, 1961, 13 *pp.* 15 *cents.*

More than 500 references to the field of temperature measurement are presented in this monograph, which was compiled in co-operation with the AE-2 Committee, Physical Measurement Sensing, of the Society of Automotive Engineers.

These references, covering the period from January, 1953, to June, 1960, with some earlier entries, were collected from two general sources: scientific and technical literature and government reports.

For convenience to the user, the references are divided into a number of categories, based on the type of instrument used, including thermo-electric, resistance, radiation, expansion, aspirated, and other devices.

Some references to calibration of instruments, and to scientific theories on which temperature measurement is based, are also included. One section discusses " nuclear applications of temperature measurement", and the last section presents " associated equipment and testing procedures".

(Order from Superintendent of Documents, U.S. Government Printing Office, Washington, 25, D.C.)

Foreign remittance must be in U.S. exchange and should include an additional one-fourth of the publication price to cover mailing costs.

Fourth Temperature Symposium

A SYMPOSIUM on Temperature—Its Measurement and Control in Science and Industry was held in Columbus, Ohio, 27th-31st March. This meeting, sponsored by the American Institute of Physics, the Instrument Society of America, and the National Bureau of Standards, was attended by over 900 scientists and engineers from the United States as well as Great Britain, the Soviet Union, Germany, Canada, Australia, and other foreign nations. More than 250 papers were presented, covering a wide range of topics. W. A. Wildhack, of NBS, was general chairman of the Symposium; other officers of the general committee were Elmer Hutchisson, AIP, vice-chairman; C. L. Roberson, ISA, secretary; and C. M. Herzfeld, NBS, programme chairman.

Because temperature plays an important role in science and in a wide range of processes, both industrial and biological, constant efforts are being made to measure and control temperature with greater accuracy and effectiveness. Topics covered ranged from near absolute zero to the temperature of the stars, from the ocean floor to the upper atmosphere. Of particular interest was the wide coverage given the role of temperature in biological and medical problems.

This Symposium was the fourth in a series started in 1919. Subsequent meetings were held in 1939 and 1954. Under the editorship of C. M. Herzfeld, the proceedings of the 1961 Symposium will be published within the next year as a three-volume edition by the Reinhold Publishing Company. The general committee for the 1961 Symposium will continue in being to decide upon and arrange a series of smaller, more specialised, conferences during the next several years. These conferences will cover areas of developing importance in the temperature field. It is felt that another general Symposium will be appropriate after 7 to 10 years.

The Symposium programme was divided into the following areas: definitions of temperature and establishment of temperature scales; principles and applications of various measuring instruments; and the applications of measurement methods in various special fields. In addition, several plenary sessions were held for the presentation of papers covering broad areas rather than specific research results. Time was allotted for open discussion after all papers excepting those read at plenary sessions. Because of the large number of papers being presented, as many as four concurrent meetings were sometimes in session.

The meeting was opened by Allen V. Astin, Director, National Bureau of Standards. In a brief address, Dr. Astin commented upon the increasing importance and difficulty of making temperature measurements. He also noted that temperature measurements are importantly related to man's attempt to understand and improve the world in which he lives.

Temperature Scales

In order to make reproducible measurements of temperature, a scale or scales must be agreed upon which can be used to assign a number to a particular temperature determination. Both the thermodynamic (Kelvin) and the International Practical Temperature Scales were discussed, and comments were made upon the means of realising these scales, as well as the differences between them. The use of fixed points, such as the triple point of water and the boiling point of sulphur, to define the temperature scales was described, as were developments in the search for more accurate fixed points. The actions of the General Conference on Weights and Measures (Oct., 1960) in revising the text of the International Practical Temperature Scale were noted[1].

With the rapid growth of cryogenic research and engineering, a need has arisen for an accurate temperature scale extending to near absolute zero. Several such scales were discussed, including the thermodynamic scale below 1°K, and the platinum resistance thermometer scale for use down to 10°K. A low-temperature thermometer utilising the Mössbauer effect was also described.

Measuring Instruments

The determination of temperature is becoming increasingly important, not only over the normal span of operating conditions, but at extremely high and low

temperatures as well. Techniques of temperature measurement must be extended to cover these regions, and must be improved in accuracy at all levels. A large number of measuring techniques were discussed at the Symposium, including both optical and non-optical methods.

Optical methods of temperature measurement include pyrometry, spectroscopy, and others. These methods are used where the temperature is so high as to destroy any instrument operating by direct contact, or where the source is inaccessible, as with the sun. Recent developments of optical pyrometers were reviewed, including photo-electric and two-colour pyrometers. Also, the use of spectroscopic analysis of the light emitted from a source as a means of determining temperature was considered in detail.

Non-optical methods were given extensive coverage in a number of sessions. The construction, calibration, and use of various types of thermocouples were outlined in detail, and the effects of intense nuclear radiation upon couples were reported. It has been found that the radiation has little effect upon the thermocouple material itself, but may cause degenerative changes in the insulators used to protect the couple, and thus result in inaccuracies.

A number of unusual temperature measuring methods were also described. The use of a thin film of metal, deposited on a ceramic backng element, was discussed. This technique, in which the film acts as a voltage divider, is useful in the measurement of temperature within shock tubes. A method of using an acoustical interferometer to determine temperatures in the liquid helium range was presented. This device permits the determination of the velocity of sound in a gas, from which, if the pressure is known the temperature can be computed. The measurement of temperature in a plasma jet, using an ablating probe, was considered, as was the measurement of the surface temperature of ablating silica.

The temperature of a gas can be calculated if the pressure, density, and molecular weight are known. A procedure by which the density of a gas could be determined by means of beta-ray attenuation, and then converted to temperature values, was outlined. A number of fusible temperature indicators, which melt at a carefully determined temperature, were reviewed. Various other techniques were described, including the measurement of temperatures of microwave noise sources, the measurement of temperature in high speed systems, and various methods of determining rocket and jet engine temperatures.

The flow of gas through an orifice, nozzle, or capillary tube is affected by temperature. Several papers surveyed and discussed measurement and control devices utilising one or a combination of these elements. Some, with water-cooled probes, have been used to measure rocket exhaust temperatures; others are designed to be usefully accurate to the temperature of liquid hydrogen.

Several papers dealt with calibration techniques used by NBS and by industry[2]. In addition, a special meeting was held at which questions concerning standards and the calibration of instruments were answered by a panel of standards and calibration experts.

Special Fields

Several sessions were concerned with the determination of temperature in special fields. Included were discussions of temperature measurements in moving systems, in cryogenics, and in geo- and atrophysics. Automatic methods of temperature measurement and control were surveyed, reflecting the growing interest in industrial automation. Methods of generating extremely high temperatures were considered, including thermal imaging, ultra-high frequency induction furnaces, and arc furnaces; and techniques for measuring these temperatures were reported.

As temperature profoundly affects the ability of living organisms to adapt to an environment, and as changes in temperature affect the metabolic activity of the organism, the importance of temperature to biology and medicine was considered in detail. Topics presented included hibernation, physiological responses to cold, acclimatisation to heat, temperature sensitivity, and life at relatively high temperatures. Methods of producing hypothermia (lowered body temperature) and the medical implications and uses of this technique were outlined.

Temperature determinations in astrophysics were also summarised. Papers included the measurement of temperature in the solar corona, solar prominences, and meteors, and the determination of temperature from the optical continuum and from spectral lines. Geophysical temperatures were discussed, including such topics as the temperature of the ocean floor, permafrost, and the upper atmosphere.

1. *Nat. Bur. Stand. Tech. News Bull.*, April, 1961.
2. *Nat. Bur. Stand. Tech. News Bull.*, March & April, 1961.

Capacitors, Inductors and Resistors at Radio Frequencies

Notes on Applied Science No. 22. *Published by the National Physical Laboratory.*

IN this Note a number of techniques which have been developed and used at the NPL in the radio frequency field are described.

Details are given of impendance measurements using resonant lines, using the dielectric test set, and using the NPL radio frequency Schering bridge.

Resonance methods described include, frequency dependence of inductance of standard inductors; effective self-capacitance of sub-divided inductors; effective self-capacitance of fixed mutual inductors; the residual inductance of two-terminal variable air capacitors; and the residual inductance of three-terminal variable air capacitors.

Information is also given on the measurement of very small capacitances and on refinements in the use of the BBC type multi-radio admittance bridge.

Copies of the publication may be obtained from H.M.S.O., price 1/9d.

FLOW-RATE MEASUREMENT TH

An Assessment of Standard Orifice Form t I

THE complexity of the flow pattern associated with flow through a pipe orifice is such that theoretical treatments are not capable of predicting the flow rate from observations of the pressure drop with sufficient accuracy for metering purposes. This is increasingly the case as the pressure taps are moved to occupy positions at which the stream lines are otherwise than straight and parallel, and as the Reynolds number falls to values where viscosity enters as an appreciable factor in determining the pattern of the flow.

In consequence, almost all data regarding the nature of flow through metering orifices and, in particular, on the wall-pressure-gradient versus flow-rate characteristic, has had to be derived experimentally.

In this connection, a study of the subject from the point of view of dimensional analysis shows that we may express the results of such experiments in terms of a number of dimensionless parameters, so chosen as to be particularly convenient either for design purposes or for assessing the physical significance of experimental data. Such dimensional treatments are also of use in predicting the flow characteristics of large-scale installations from the results of experiments on models, and also ensure that the number of variables used to describe a phenomenon is reduced to a minimum.

Thus, in the case of incompressible (adiabatic) flow through an orifice installed in a pipe of diameter D, dimensional considerations, in the form of applying Buckingham's pi-theorem, lead to the non-dimensional equation

$$\alpha = \phi\ (R, l_1/D, l_2/D \ldots\ldots)^* \quad \ldots\ (1)$$

where, referring to Fig. 4 (Part I),
α and R are, respectively, the (velocity of approach inclusive) flow coefficient of the throttling device and the Reynolds number of the flow in the unconstricted stream, as defined by the equations

$$\alpha = \frac{Q}{A_o} \frac{1}{\sqrt{2\,p/\gamma}} \quad \ldots\ldots\ldots\ldots\ (2)$$

and $R = VD\gamma/\eta \quad \ldots\ldots\ldots\ldots\ (3)$

in which expressions, and subsequently,

- p = the wall pressure drop as registered between the upstream and downstream pressure tappings consequent on establishing a bulk volumetric (upstream) flow-rate Q
- A_o = cross-sectional area of the throat of the orifice
- γ = the upstream value of the fluid density
- η = the upstream value of the viscosity
- V = mean velocity in the unobstructed stream as defined by the relation $V = 4Q/\pi D^2$ and
- $l_1, l_2, l_3 \ldots$ are linear dimensions (other than D) which define the geometry of the installation.

For geometrically similar installations equation (1) reduces to the form

$$\alpha = \phi\ (R) \quad \ldots\ldots\ldots\ldots\ (4)$$

The derivation of equation (1) is given in a previous study[1] on the dimensional treatment of converging ducted flow. Although by no means representing the only choice of working parameters which may be derived from such dimensional considerations, the formula is a particularly convenient choice in so far as it expresses p explicitly in terms of Q. Furthermore, when the flow pattern is independent of viscosity, we may write equation (1) in the form

$$\alpha = \phi(l_1/D,\ l_2/D \ldots) \quad \ldots\ldots\ (5)$$

an equation which governs flow under conditions where only inertia forces are effective in determining the pattern of the flow.

* Absolute or mass-system units in which the dimensional formulæ of all quantities assume the form $[(\text{mass})^x \times (\text{length})^y \times (\text{time})^z]$ are used throughout this paper.

ENTH ORIFICE PLATES

ort II. Presentation of Experimental Results

By T. H. REDDING, M.Sc., F.Inst.P., A.M.I.Mech.E.

Orifice Calibrations

Previous to their introduction as standard metering devices, and to a lesser degree subsequently, both the A.G.A.-A.S.M.E. and I.S.O. orifices formed the subjects of extensive experiments to determine relevant flow coefficient data over a wide range of Reynolds numbers in various sizes of main.

A.G.A.-A.S.M.E. orifice

Calibration data for this pressure difference device, as accepted by the A.G.A. (in 1955) and the A.S.M.E. (in 1959) for purposes of meter-standardisation is given in refs. 2 and 3 respectively—the relevant data in both these documents still being based, in the main, on the work of Beitler[4] who, as previously mentioned, originated this particular orifice form. However, whilst the A.G.A. and A.S.M.E. publications refer only to coefficients relating to vena-contracta, radius, flange and pipe tappings, Beitler's experiments included the determination of coefficients when corner taps are used.

References 2 and 3 are, in effect, later editions of refs. 5, 6 and 7, which publications themselves stemmed from the deliberations of a joint A.G.A.-A.S.M.E. Committee on Orifice Coefficients[8] which based its recommendations almost entirely on Beitler's results.

As far as coefficient data is concerned the new editions of both the A.G.A. and A.S.M.E. codes differ from the earlier ones in the following respects:

(a) coefficients are given to cover larger pipe diameters and higher Reynolds numbers than hitherto

(b) in some instances, particularly for large mains working at high Reynolds numbers, extrapolated values of the coefficients are preferred to the experimental values previously quoted

(c) some revision, based on new experiments, has been effected for orifices having very small area ratios†

(d) coefficients are given which relate to radius and, in the case of the A.S.M.E. publication, to corner taps and

(e) in *all* cases values of the coefficients are those derived from empirical formulæ designed to fit the experimental curves.‡ Also, in both publications, coefficients are now expressed in their "velocity of approach inclusive" form, i.e., they refer to values of the coefficients as given by the quantity α in equation (2): previously both the A.G.A. and A.S.M.E. codes had followed Beitler and quoted coefficients in terms of C, where $C = \alpha (1 - m^2)^{\frac{1}{2}}$. The new A.G.A. code also gives references to reports of the experiments made to effect the above extensions of coefficient data.

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† This became necessary because, at very small area-ratios (where the condition $b_2 < d/8$ prevails), the edge thickness of the *actual* orifice used in Beitler's experiments did not quite conform to the specification of the standard orifice given by Fig. 6 (Part 1).

‡ Previously (in refs. 5, 6 and 7) this was only the case for coefficients relating to flange and pipe taps, those coefficients relating to vena-contracta taps being smoothed experimental values or, when outside the range of experiment, the result of graphical extrapolation of experimental data. Furthermore, in these earlier publications, no values are given for coefficients relating to radius or corner taps, although ref. 8 (on which refs. 5, 6 and 7 are based) gives empirical formulæ for their evaluation. These formulæ, together with the aforementioned formulæ for flange and pipe coefficients are the result of a National Bureau of Standards evaluation of Beitler's results as included in summary form in ref. 8. In so far as coefficients relating to flange and pipe taps are concerned these formulæ, with slight modifications, have been retained in the more recent A.G.A. and A.S.M.E. codes (refs. 2 and 3).

For comparative purposes, Figs. 9, 10, 11 and 12 show flow characteristics "α versus R" for corner, vena-contracta, flange, and pipe-tapped A.G.A.-A.S.M.E. orifices. All these curves derive from empirical formulæ designed to fit Beitler's experimental results, and, with the exception of Fig. 9, these formulæ are as given in Art. 307 of ref. 3. In the case of coefficients relating to corner taps, however, the formula given in the older "Joint" report[8] has been used. This is because the values for corner-tapped coefficients, as given in ref. 3, take into account other results besides those of Beitler: furthermore, they do not differentiate between the coefficients relating to different diameter mains, except in so far as greater tolerance-limits are assigned to those coefficients which relate to smaller diameter mains.

Although Beitler's experiments extended to pipes as small as 1 in. diameter, coefficient data is not recommended (in either A.G.A. or A.S.M.E. publications) for pipe diameters less than 1·5 in. where vena-contracta or flange taps are concerned, or less than 2 in. where pipe taps are used. This again is in accordance with a recommendation of Beitler[9] which, in effect, recognises the importance of the appreciable effects of variation in pipe roughness and errors of centring which so easily arise when orifices are used in small diameter mains.*

Summarising the principal characteristics of the curves shown in Figs. 9, 10 and 11 we notice that, in all cases, α increases with decreasing R and m and that, at high Reynolds numbers, $d\alpha/dR$ tends to become increasingly small.

Furthermore, for all but the smaller values of m (i.e., $m<0{\cdot}16$) the flow coefficient at high Reynolds numbers tends to increase with decreasing pipe diameter, the effect decreasing with decreasing m and being least marked when vena-contracta taps are used. Again, except at low values of m, the coefficients relating to vena-contracta and flange taps at high Reynolds numbers are in excess of those relating to corner taps by an amount which decreases with decreasing m. In those regions where the coefficient is appreciably dependent on the Reynolds number, it is so to an extent which increases with increasing area ratio and increasing pipe diameters; moreover the Reynolds number dependence of the coefficient is least when vena-contracta taps are used.

The physical significance of these and of other properties of the α versus R flow characteristics, as may be explained in terms of probable changes in the flow pattern before, within and after the orifice, is discussed at some length in a previous publication[10].

* The aforementioned (National Bureau of Standards) formula for coefficients of corner-tapped orifices extends to 1 in. diameter pipes and Fig. 9 shows a curve calculated for a 1 in. main. However, as with flange and vena-contracta taps, it would seem imprudent to regard such coefficients as acceptable standards when the main diameter is less than 1·5 in. Again, in view of lack of precise information as to what may be regarded as the respective ranges of experimental and extrapolated corner-tapped coefficients, these are shown (in Fig. 9) as for flange taps when D = 10 in., as for vena-contracta taps when D = 1 in. and intermediately when D = 3 in., these being respectively the nearest tapping positions for which definite information is available regarding the respective ranges of experimental and extrapolated coefficients.

I.S.O. orifice

Calibration data for this pressure difference device, as accepted in 1935-36 by the (then) I.S.A., are given in refs. 11 and 12—the relevant data being based, in the main, on the experimental work of Witte[13, 14, 15, 16] who originated this orifice form.

However, more precise values of the coefficient, particularly at low Reynolds numbers (and relating to the "revised" I.S.O. orifice for which $b_2/D \leqslant 0{\cdot}02$), are given in the 1948 edition of the German code D.I.N. 1952 (ref. 17).

Unlike the A.G.A. or A.S.M.E. codes, the I.S.O. documents give emphasis to corner-tapped installations and assume that the general case of the coefficient relating to corner taps can be derived as the product of a "base" coefficient, α_o say, and operational correction factors k_D and k_R in the expression

$$\alpha = k_R k_D \alpha_o \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

where α_o is the coefficient relating to a corner-tapped orifice installed in a pipe of diameter greater than 12 in. working at Reynolds numbers in excess of that for which α is sensibly independent of R, and where k_D and k_R are operational correction factors which, respectively, take into account the diameter of the main and the Reynolds number of the flow.

Values of α_o, k_D and k_R, according to the I.S.O. specification, are shown in Fig. 13 whilst Fig. 14 shows the over-all display "α versus R for selected values of D" (as calculated from equation (6)) in the same manner as previously adopted for presenting calibration data for orifices of the A.G.A.-A.S.M.E. form.

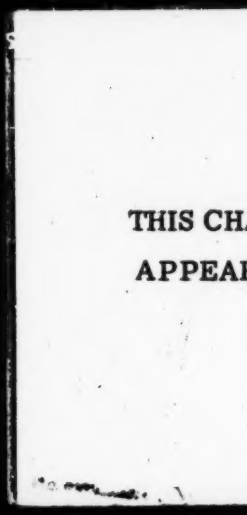
As far as the author is aware, equation (6) is the result of data-analysis of extensive but uncoordinated information on the I.S.O. orifice coefficient rather than the result of systematic experiments to determine the independent and combined effects of the independent variables R and D. In particular, the principal data on the effect of pipe diameter relates to calibrations at Reynolds numbers almost entirely within the range for which α is sensibly independent of R. However, on analysis, the recent results of E. A. Spencer and P. J. McNulty[18] on orifices in 3 in. and 6 in. diameter mains confirm the "product form" of equation (6). Beitler's results for corner-tapped orifices (as shown in Fig. 14) cannot be expressed in the form of equation (6) without admitting to a tolerance limit well in excess of either the tolerances specified by the A.G.A., A.S.M.E., or I.S.O. codes.

Although the I.S.O. code only gives values for the coefficients relating to corner taps, it is possible to calculate the coefficient for other positions of the pressure taps if the pressure gradients upstream and downstream of the orifice are known.

Thus, if P_1' and P_2' are the wall-pressures relating to taps at distances a_1 and a_2 upstream and downstream of the orifice and P_1 and P_2 are corresponding pressures relating to corner taps (see Fig. 4, Part I) we have

$$\alpha_{RDl_1l_2} = \alpha_{RD}\left\{1-\left[\left(\frac{P_1-P_1'}{P_1-P_2}\right)-\left(\frac{P_2-P_2'}{P_1-P_2}\right)\right]\right\}^{-1/2} \quad (7)$$

where α_{RD} and $\alpha_{RDl_1l_2}$ are coefficients relating to flow in a main of diameter D working at Reynolds number R with pressure tappings respectively in the corner positions and at distances l_1 and l_2 from the orifice.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This formula follows from the expressions defining α_{RD} and $\alpha_{RDl_1l_2}$.

In this way, and with reference to the results of pressure gradient experiments by Witte[15] (shown in Fig. 15), values have been computed for the coefficient of the I.S.O. orifice when vena-contracta and flange taps are used: these are shown in Figs. 16 and 17 respectively.† However, in making such calculations it has been assumed (after Witte) that $(P_1-P_1')/(P_1-P_2)$ and $(P_2-P_2')/(P_1-P_2)$ are independent of Reynolds number and pipe diameter. Since Witte's experiments on pressure gradients do not cover the full range of Reynolds numbers shown in Figs. 16 and 17, it should be assumed that, to some degree, these coefficient curves are approximate over that part of their range where α is sensitive to changes in R—particularly in view of experiments by Engel[19] and Johansen[20] who report a slight increase in $(P_1-P'_1)/(P_1-P_2)$ with increasing Reynolds number. Nevertheless the 4th (1937) and subsequent editions of the V.D.I. Flow Code[17] incorporate Witte's pressure gradient data with given tolerance limits without restricting the range of Reynolds number over which it may be applied.

In all cases the I.S.O. characteristics follow the same general trend as those relating to the A.G.A.-A.S.M.E. device except that at high Reynolds numbers the diameter-dependence of the I.S.O. coefficient is independent of the position of the pressure taps‡ and the Reynolds number dependence is independent of both pipe diameter and the position of the pressure taps.

† Witte's results show that, to a small extent, both upstream and downstream wall-pressures depend on the diameter of the tapping-hole used to determine them: the curves shown in Figs. 16 and 17, being derived from pressure gradient data given in Fig. 9, relate to a tapping-hole diameter equal or less than 0·1D.

‡ Acceptance of the I.S.O. data for other than corner taps would, in fact, refute the author's previously mentioned preference for vena-contracta taps on the grounds that, according to Beitler, the relevant flow coefficients are much less dependent on pipe diameter than is the case for corner- or flange-tapped installations.

(Part III will be published next month.)

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News from

BISRA

THE British Iron and Steel Research Association has created a new section in its Plant Engineering and Energy Division to centralise the Association's research into control engineering.

When the Plant Engineering and Energy Division was formed, an Electrical Engineering Section was included to carry out research into the electrical equipment used in steelworks. During the last few years, and with the increasing interest being shown in automation in the iron and steel industry, the research of the Section has tended more and more towards the electrical engineering aspects of automatic control systems—their design, construction and application to steelworks plant. Some work on hydraulic control systems has also been carried out in another section of the Division. The basic theory of control applies to both, and the one selected depends upon the specific requirements.

In view of the advantages to be gained in bringing all the work in the Division on control engineering within the province of one section, the Electrical Engineering Section has been replaced by a new Control Engineering Section.

The change of name is a recognition of the gradual change of emphasis in this field of work; the new section will continue the present research into the electrical engineering problems of steelworks, with the addition of work on hydraulic control.

The Association has appointed Mr. J. P. Clyne, M.A., A.M.I.E.E., Grad.I.Mech.E., who has recently joined BISRA from the Sperry Gyroscope Company Ltd., as head of the new section.

Analogue Simulation of Cold Tandem Mills

An analogue computer has recently been installed at BISRA's Battersea research station to facilitate studies of cold tandem mills. Investigations are being directed towards establishing an optimum system for automatic gauge control.

As shown by Hessenberg and Jenkins*, small variations in tension, gauge, and speed of strip in a cold tandem mill are related mathematically by simple linear simultaneous equations. By employing an analogue computer which is provided with individual units for summation, multiplication and integration it is possible to simulate the operational conditions of such a mill. The units are connected to form a term-by-term description of the equations, so that the voltages in the computer behave in the same way as the variables in the mill itself.

This electrical model, or analogue, of the mill will respond to any external influences such as changes in input gauge, speed or screw settings, in the same way as the original mill, and the effects of these on any mill variable can be measured. A wide range of mill control systems can therefore be investigated by feeding typical input gauge profiles into the analogue. By these means it is hoped that an optimum system for automatic gauge control will ultimately be established.

The technique is capable of considerable refinement. It is possible, for example, to include roll eccentricity and hydraulic roll force actuation if required, and it may also be possible to simulate gauge control on a mill during running up or slowing down.

One of the advantages of the technique, apart from its extreme flexibility, is that, once the analogue has been set up, it is no longer necessary to occupy a production mill for control system experiments, other than for occasional checks to verify phenomena observed on the analogue. When setting up an analogue of a specified mill, however, it is necessary to carry out some experiments on that mill in order to obtain essential numerical data.

Continuous Inspection of Wire

New equipment which is being introduced into wire mills will make it unnecessary for a wire drawing operator to stop his machine after drawing 2-4 cwt of wire to remove the coil from the machine. Coil weights can now be increased and in the near future 2 ton coils will become quite general. Less handling and welding will be needed for these larger coils, but it will still be necessary to stop the drawing machines in order to check that the surface finish and the diameter of the wire are within the required tolerances. The development of a satisfactory instrument for the continuous inspection of wire on in-line machines would eliminate the need for these stoppages and would reduce the percentage of wire rejected for gauge or surface defects, particularly on high speed machines. Although, as yet, there are no instruments available for the continuous inspection of surface finish or the detection of score marks, considerable advances have been made in automatic gauging techniques. BISRA has made a survey of the wire gauging instruments currently on the market, classifying them as contact or non-contact.

Proc. Inst. Mech. Eng., **169**, 1955, pp. 1051–1058.

Contact gauges may be operated by mechanical, pneumatic or electrical means, but whether the instrument uses a dial gauge, a pneumatic transducer, or a calibrated differential transformer, the basic design is the same. The moving wire passes between rolls or styli, and a sensing unit measures the deviation of the wire thickness from a standard diameter; an alteration in gauge causing an error signal to be displayed.

For use on fine wire, non-contact gauges have advantages. There is no wear of moving parts and no danger of marking the wire, which is particularly important as a very good surface finish is demanded for many types of fine wire. There are three categories of non-contact gauge—electrical (capacity), pneumatic and the optical type using photo-electric cells.

In a gauge of the capacity type, the wire passes between two sensing elements. Any variation in wire size affects the capacity of the wire and hence an error signal warning of the change in gauge can be generated. In a pneumatic non-contact gauge the wire passes through a narrow tube, one wall of which is pierced by the neck of a chamber connected to a measuring device. Air from a constant pressure supply source is fed into this chamber and passes up into the tube. Since the clearance between the wire and the walls of the tube is extremely small, the moving wire acts as a seal to the chamber controlling the escape of air. Thus, any variation in the gauge of the wire will cause a variation in pressure within the chamber and will be detected by the measuring unit.

Optical gauging instruments make use of photo-electric cells in different ways, the simplest method employing a measuring cell and a reference cell. It is, however, possible for both to be combined in a single unit.

Wire Temperature Measurement

Efficient operational control in wire mills is at present limited by the lack of an accurate device for measuring wire temperature. If full advantage is to be taken of the higher drawing speeds that engineering and electrical machine design now make possible, it is necessary to ensure that the temperature of the wire, as it is drawn through the dies, does not rise so high that the properties of the wire or of the lubricant are impaired. With a suitable temperature-measuring instrument the maximum drawing speeds can be quickly established for various steel qualities and for different drafting schedules. The instrument could be the basis of future systems of automation and process control in wire-drawing mills, and could also be used for measuring the temperature of wire during heat treatment and in "in-line" cleaning and coating.

A reliable instrument has recently been developed for this purpose by the Addison Electric Co. Ltd. in collaboration with BISRA. In the Addison meter a reading is obtained by pressing two pulleys, made of different metals forming a thermocouple, against the moving wire. The signal generated is passed through contacting brushes on the pulleys, and a connecting lead, to the measuring unit. The meter has been specifically designed for the rapid temperature measurement of moving wire and the response time is normally only 5-10 seconds. The temperature is indicated directly on a calibrated scale in the measuring unit.

The instrument has been calibrated, on a special rig developed by BISRA, over a speed range of 50-3,000 ft/min, a temperature range of 50-300°C, and wire sizes from 9-16 s.w.g. The meter reading is independent of wire size and speed over the ranges tested. Accuracy is ± 5°C, which is considered to be adequate for industrial needs.

The calibration is not affected by the type of phosphate coating normally used for the drawing of high-carbon steel wire, and theoretically there are no reasons why it should be affected by tin or zinc coatings provided there is no temperature difference in the wire between the contact points on the pulleys. The problem of temperature measurement on heavily soaped wire, where it has been found that the soap transferred to the pulleys may act as an insulator, thus preventing more than one reading without cleaning, has been overcome by fitting paraffin impregnated pads that are spring loaded on to the pulleys: in this way a clean surface is always presented to the pulleys.

The Addison contact meter has proved itself in the laboratory and in industrial wire mills during extensive experimental studies. Preparation for use, by zero setting and adjustment for ambient temperature, is easy and takes less than half a minute, and the only other precaution needed is to ensure that the pulleys are clean and that the pads are impregnated with paraffin.

The instrument is of robust construction, and the measuring unit, containing the meter, is self-contained in a case approximately 10½ in. × 10½ in. × 4½ in. and weighs just over 5 lb. An optional extra is an ever-ready leather case with a strap so that the instrument can be slung from the neck during use.

Strip Speed Measurement

During the rolling processes needed to reduce the thickness of the steel, much of the work hardening is unevenly distributed and causes wide variations in temper. The final temper is obtained by annealing the whole sheet so that it is "dead soft" and then passing it through a temper mill which makes a small thickness reduction.

Temper mill thickness reductions are usually in the range of 1–3% and operation speeds vary widely. Some mills work at only 500 ft/min, others at 4,000 ft/min. In order to carry out efficient temper control an accuracy of 0·1% is necessary for thickness measurement.

Thickness may be measured either directly or indirectly; but the methods available for direct measurement—involving the use of nucleonic gauges and flying micrometers—do not give sufficient accuracy. This may be more readily obtained by comparing the input and output mill speeds.

The method developed by BISRA to accurately compare input and output speeds does not involve contact with the material or rely on any magnetic or electrical properties.

Basically, the instrument depends upon the accurate measurement of the time taken for any given part of the strip to pass over a fixed distance. The principle underlying this measurement is as follows. The images of

two electric lamp filaments are projected on to the moving strip at a fixed distance apart from each other, and at each point a photo-electric cell picks up the reflected light. Because of surface imperfections caused by the grain structure of the metal and the texturing of its surface, the reflected light received by the photo-electric cells fluctuates as the strip passes beneath the beams creating the filament images. If the two filament images are placed in line, so that the same parts of the strip surface pass under both, the signals transmitted to the actual measuring device will be virtually indentical apart from the time delay involved.

The signal from the first photo-electric cell is recorded on magnetic tape by a writing head. The tape is moving at a constant speed and the signal is then brought under a reading head whose distance from the writing head may be varied manually. This signal is finally relayed from the reading head to a correlator. The correlator also receives direct the signal from the second photo-electric cell picking up reflected light from the second filament image on the moving steel strip.

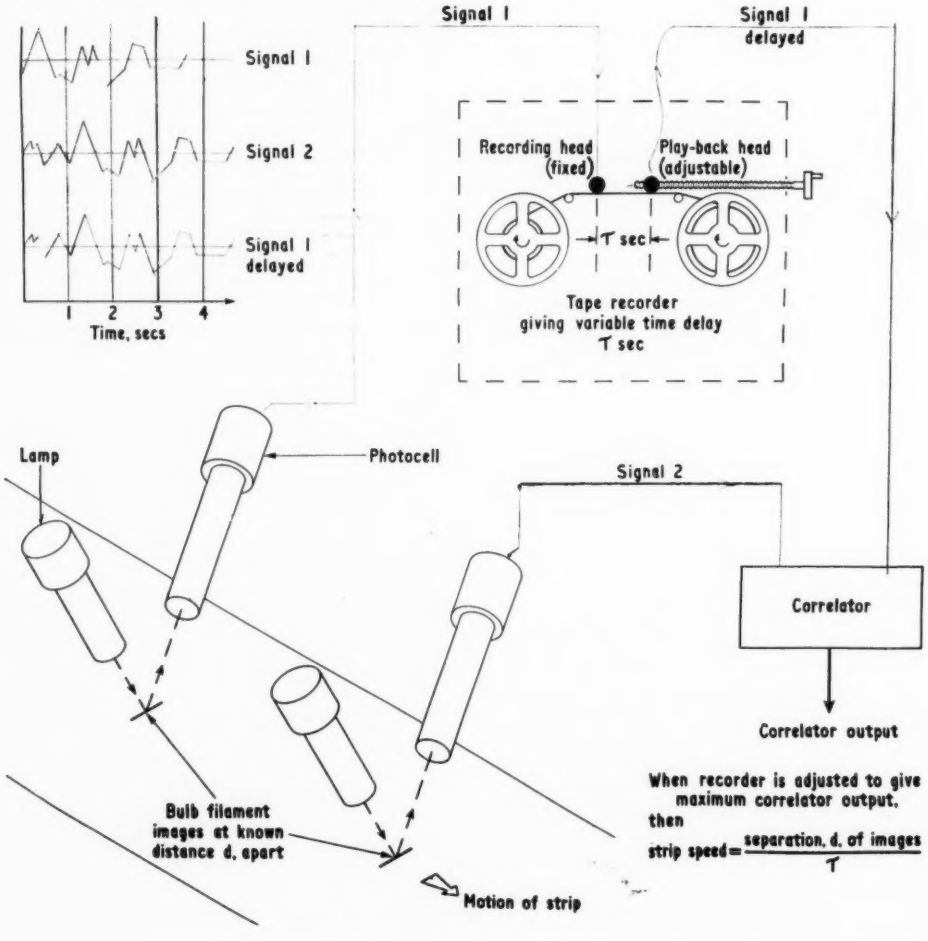
By manually adjusting the distance between the writing head and the reading head, the correlator can be made to provide the maximum output signal. This occurs when the signal relayed from the tape recorder and the signal taken direct from the moving steel strip are synchronous, and in this case the delay introduced by the tape recorder is equal to the transport delay of the strip between the two filament images.

It is now possible to determine the actual speed of the strip as follows:

The delay in the tape recorder is given from the known speed of the tape and the distance between the writing and reading heads. As explained above, this delay is equal to the transport delay of the strip between the filament images. Since the time taken for the strip to pass between the filament images and the distance between them are both known the strip speed follows immediately.

Preliminary tests on a temper mill with the experimental prototype strip speed meter have shown that it is possible to obtain an overall accuracy better than $\pm 0{\cdot}1\%$.

Principle of strip speed measurement



MINIATURISATION OF AIRCRAFT COMPONENTS

THE ENGLISH ELECTRIC Lightning, said to be the most technically-advanced aircraft in service, is an all-steel plane with two jet engines mounted one above the other. Although the Lightning has been in service with the R.A.F. since May, 1960, security had delayed its first public showing until Wednesday, 12th July, 1961, when a Press visit to the Lancashire works was arranged. Of course, a modern fighter has many more instruments than the equivalent civil aircraft, and yet the need for maximum manœuvrability makes it mandatory that each piece of apparatus must be as light and small as possible. This has been a major factor in bringing about the miniaturisation of electronic components and, as the visit showed, a number of new manufacturing techniques.

A special use of automation took the place of templates on some of the drilling and milling machines. Instead of using a cut-out template to guide the tools, a special magnetic tape was used. This carried an electronic track whose signals controlled the machine according to the programme prepared on it to match the works drawing. Ordinary ¼ in. magnetic tape was used and the operator need not be a fully-skilled machinist. The test rooms in the factories visited are specially dust-proofed and all wiring and hydraulics can be fully checked without dust entering from the factory floor.

Space in the cockpit of the Lightning is at a premium and so only one fitter can work there at a time during the final stages of assembly. For this purpose, therefore, a duplicate instrument board has been constructed, which can be paralleled to the cockpit instruments. The procedure then was to check each instrument singly with one inspector in the cockpit and another reading the test board on the ground. The inspectors were in headphone contact using an intercom. set.

The Lightning aircraft are finally assembled at Samlesbury in Lancashire and flown to the nearby test airfield at Warton. Here a special flight simulator room has been built which allows the pilots and indeed sections of the aircraft electronics to be given realistic operational tests. In addition to this, a two-seater version of the Lightning has been constructed for training purposes. Its cockpit is some 11 in. wider and all important instruments and controls have been duplicated.

Magnetic tape is again used during all flight tests. The pilot's commentary plus his verbal instructions from the ground are recorded in the ordinary way and, synchronised with this, special telemetering equipment displays the cockpit meter readings in the Flying Control room and records it for future reference. Telemetry recording equipment is also carried in the aircraft.

A new and improved version of the Lightning, called the Mark II, is now being produced, and amongst other refinements carries an improved air-to-air guided missile.

JOHN BORWICK

Ergonomics In Industry

OVER 300 delegates from industry, the trade unions, universities, research associations and government departments attended the 3-day D.S.I.R. Ergonomics Conference in London last September. The Proceedings of the Conference* include all the papers and a verbatim report of the delegates' discussions.

Ergonomics, the scientific approach to the problem of fitting the job to the worker, is aimed at improving industrial efficiency by designing equipment so that its operation is within the mental and physical capacities of the average person. The purpose of the conference was to bring ergonomics to the notice of senior people in industry and to provide an opportunity to discuss its wider implications—in particular where ergonomics fits in with the interests of production engineering, equipment design, work study and industrial health.

* The proceedings are published for D.S.I.R. by H.M.S.O., price 12s. 6d., ($2.25 U.S.A.) by post 13s. 4d.

Reference Tables for Thermocouples (Copper v. Constantan) (B.S.1828 : 1961)

THE British Standards Institution has published another set of reference tables for the purpose of converting thermocouple voltages into equivalent temperatures. The new tables are published as B.S.1828: Reference Tables for Thermocouples (Copper v. Constantan).

Like the other reference tables in this series (B.S. 1826 and 1827), they are based on the International Temperature Scale, 1948, and on the Absolute Volt which, in 1948, was adopted as the standard unit in place of the International Volt.

The electromotive force/temperature curve adopted as a basis for the tables is one typical of the wire supplied by British manufacturers, since, after extensive research, it has been found impracticable for British wire manufacturers to produce copper-nickel alloy in bulk which will give values in accord with the tables of the United States National Bureau of Standards.

Copies of this Standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1, price 6/- each. (Postage will be charged extra to non-subscribers.)

High-speed Motion Picture Camera

A MOTION picture camera for filming and timing high-speed motion simultaneously in colour and black and white has been developed by the U.S. Naval Ordnance Laboratory in Silver Spring, Maryland.

Capable of exposing film at 1/50 millionth of one second without losing picture quality, the camera uses a constantly open lens which receives the image.

The camera records single frame action at 20 billionths of a second while taking one million frames per second.

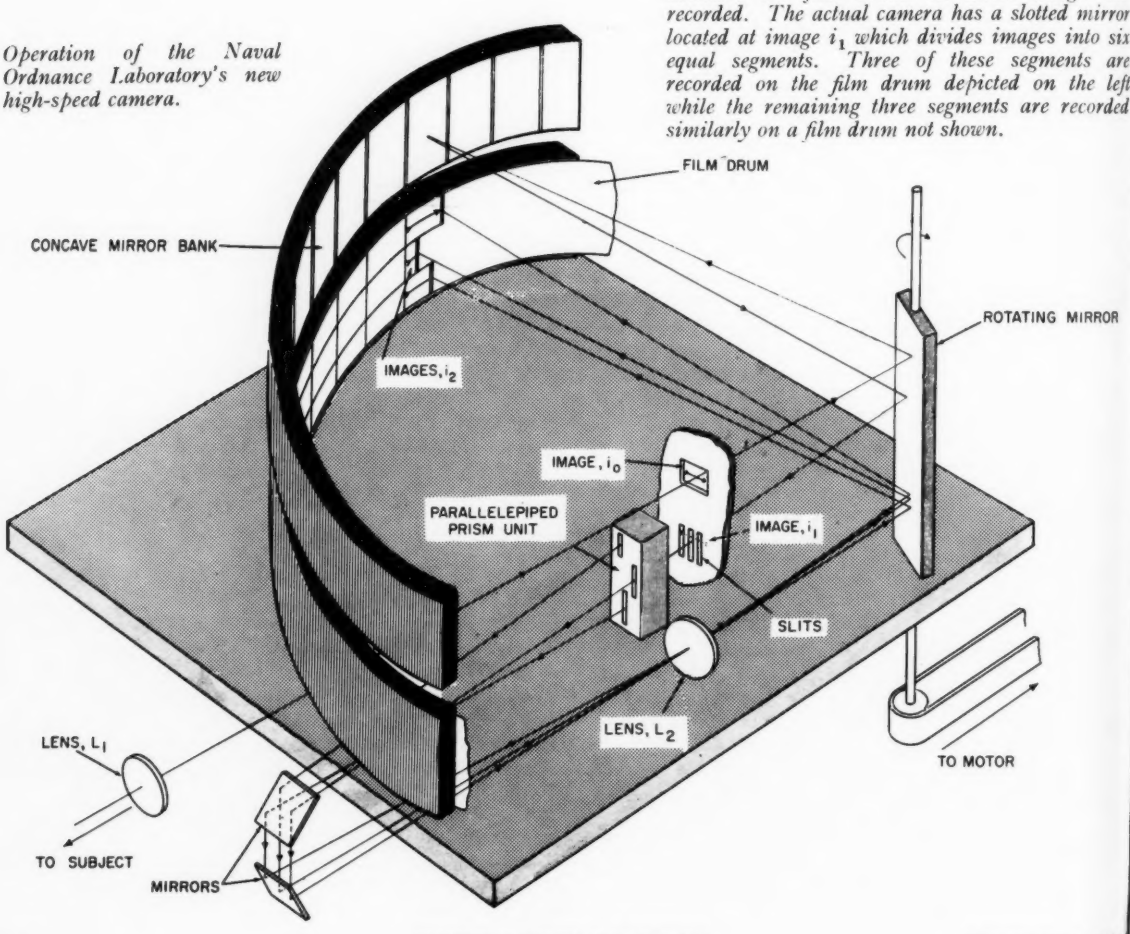
Credited with designing the unique framing camera is Dr. Sigmund J. Jacobs, Silver Spring, Maryland, of the Explosions Research Department at the Naval Ordnance Laboratory in Silver Spring, Maryland.

According to Dr. Jacobs, the camera's extremely low exposure time and twin-exposure feature are attributed to the first known application of the focal plane shutter principle in a motion picture camera.

Found in some still cameras, this type shutter is essentially a narrow slit that is passed between an image and the camera's unexposed film. Only that portion of the image seen through the slit is exposed on the film at any given time. Change in exposure with this type shutter is made by varying the width of the slits.

Operation of the Naval Ordnance Laboratory's new high-speed camera.

The diagram is simplified to show only one of the camera's two film drums on which images are recorded. The actual camera has a slotted mirror located at image i_1 which divides images into six equal segments. Three of these segments are recorded on the film drum depicted on the left while the remaining three segments are recorded similarly on a film drum not shown.



Basically, the camera is a drum-shaped device separated into two decks with a single rectangular mirror which rotates vertically through the centre of both decks. Contained in the upper deck is a bank of small concave mirrors around one wall, and a special unit consisting of a slotted mirror and a number of slits which act as focal plane shutters. This deck also houses various fixed mirror and lens units for relaying images. The lower deck of this camera houses additional relay mirror and lens units as well as a stationary film track on either wall.

During operation a continuous image is received by the camera's open lens in the upper deck where it is reflected back by way of the rotating mirror on to the bank of concave mirrors. These mirrors generate a sequence of images which are reflected back by way of the rotating mirror to the focal plane shutter system. At this point, the images are divided into six equal segments by the slotted mirror and moved past respective shutter slits.

The optical system which follows relays the images seen by the shutter slits to the two film tracks on the lower deck, again by way of the rotating mirror. Three independent trains of images are brought to rest on each of the two film tracks by virtue of a compensating motion supplied by the last reflection from the spinning mirror.

A change in exposure for either of the two film tracks is easily made by varying the width of their respective shutter slits. As a novel feature, slow-emulsion colour film can be exposed on one film bank to record subtle variations in colour, while fast black-and-white film in the other bank can stop the motion effectively. On one bank three different exposure levels could be used to record high explosive events with greatly varying light outputs.

SIMA Notes

Enquiry Service

The SIMA Enquiry Service continues to expand and in particular an increase of over 50% in the enquiries received from the U.S.S.R. is an excellent indication of the interest raised due to the participation of SIMA in the British Trade Fair in Moscow, coupled with our successful visit to Moscow in 1960.

Another matter for satisfaction is the reaction to the Direct Mail Campaign which has already resulted in a number of enquiries from overseas asking for further details of the service offered, including many who are surprised that the service is free.

I.E.A. Exhibition Committee

Owing to the sudden death of Mr. P. D. Canning, Mr. L. A. Woodhead, the SIMA representative, has now assumed the chairmanship of the Exhibition Committee.

Terms of Contract Negotiations with the U.S.S.R.

Negotiations have taken place with the representatives of the U.S.S.R. State Purchasing Organisation during their visit for the Soviet Trade Fair and considerable progress has been made towards mutually agreeable terms. Final drafts of the proposed amendments which will apply to SIMA members are awaiting ratification from Moscow.

Amendments to the Articles of Association

At the last Annual General Meeting an amendment to the Articles of Association was passed which removes certain restrictions and brings the policy regarding membership in line with present-day trends. In brief, the qualifications for membership are now:

(a) to have been established as Scientific Instrument Manufacturers for a period of three years
(b) to own, lease, or operate manufacturing capacity for Scientific Instruments in the United Kingdom
(c) to employ a majority of workmen, specialists, technicians, management, etc., of British Nationality.

It is, of course, envisaged that this amendment coupled with the current drive in recruiting will result in a further addition to the ever-growing membership of the Association.

British Instrument Directory

The next issue, at present well under way, will be published to coincide with the I.E.A. exhibition in 1962. Over 4,000 copies will be distributed free to official bodies, government buying departments and other organisations throughout the world. The total print order will be in the region of 9,000 copies.

SIMA Annual Convention

The Tenth Annual Convention is being held at the Grand Hotel, Eastbourne, in November. The theme for the Convention will be " Exports ". The Chairman of the Convention Committee is Mr. S. R. Wilkins, of Avo Ltd.

Anglo-Yugoslav Trade Council

The Director, Capt. R. A. Villiers, C.B.E., has been appointed as the Association representative on the Technical and Industrial Section of the Anglo-Yugoslav Trade Council.

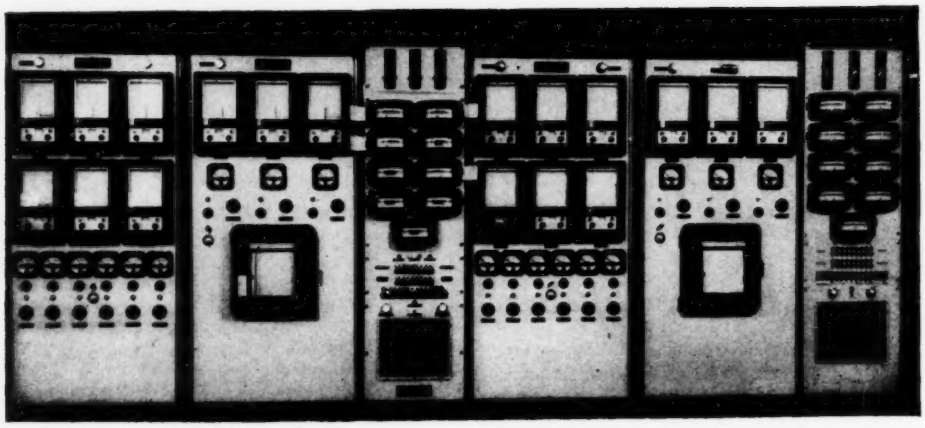
Inter-firm Comparison

Following on the success of the 1960 Inter-firm Comparison Group, a further scheme is being initiated for 1961 and a number of additional members are taking part in this second venture.

Meetings

The next meeting of the Nucleonic Group and Electronics Section will take place at the Connaught Rooms on Tuesday, 19th September.

Circle **351** for further information



Complex problem at A.E.R.E. Harwell solved by Speedomax

The problem arose at Harwell of how to control within limits of ±1°C the temperature of Specimens being irradiated within the Pluto reactor and to ascertain the **effect** of known temperatures on these Specimens. Additionally, metallurgists required to know the result under identical conditions of control in an "out of pile" experiment which would simulate exactly all changes occurring in the reactor.

The equipment comprises 18 heater channels controlled by Speedomax "H" recorders with integrally mounted 3 term controllers working into 3 K.W. Saturable core reactors, with associated monitoring and safety circuitry.

Complicated ? Yes, very, but Leeds Northrup are accustomed to solving complex problems.

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INSTRUMENT PRACTICE

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Decade Resistor Box

THE decade resistor box Type RD2 from Lionmount & Co. Ltd. is a switched unit covering the range 1 ohm to 10,000 ohms with 4 dials.

It has been designed for use primarily in development laboratories and technical colleges where medium accuracy is required, and where low price, robustness and convenience are important considerations.

The resistors are non-inductively wire wound with a copper-nickel alloy, and have been temperature stabilised. The maximum current marking on each decade is, 600, 200, 60 and 20 mA, but this value may be exceeded by 50% for short periods.

The accuracy of adjustment is better than 0·2% at 20°C, except for the lowest decade for which it is 1%.

Conventional switches having a minimum contact resistance of less than 6 milli-ohms are used, and these will give an extremely long life providing that the decade box is used with non-reactive circuitry.

The instrument is of rigid construction, having a solid mahogany case with a 3/16 in. thick stove enamelled front panel. An internal aluminium liner is fitted which makes contact with the front panel, and this provides totally enclosed screenings for the switches.

The size is 3 × 3¼ × 12 in. (7·6 × 8·2 × 30·5 cm). Weight is 2½ lb (1·14 kg).

Circle **1** *for further details.*

Glass-Fibre Insulated Flexible Cable

BRITISH INSULATED CALLENDER'S CABLES LTD. announce the availability of a flexible glass-fibre insulated cable for use as a light fitting connection. This is an addition to their existing range of miscellaneous cables.

The new cable, which is suitable for 250-volt operation, is specially designed to function at the high temperatures likely to be encountered in contemporary lighting fixtures used for illumination in modern office blocks, large stores and in enclosed show cases.

In its natural state, the glass fibre used for the insulation—treated with a suitable form of varnish binder and filler—will not burn or carry flame. Should the cable be subjected to an external source of heat, with temperatures of up to 180°C, the insulation and conductor remain intact, permitting a continued flow of electricity.

Circle **2** *for further details.*

"Micro-Lite" Miniature Lamps

THE Atlas "Micro-Lite" micro-miniature lamp is to be marketed by the Special Products Division of Thorn Electrical Industries Ltd. Available in four basic versions, the "Micro-Lite" is an extremely small incandescent lamp suitable for use with precision measuring instruments, electronic computers, push-button lights, and micro-photographic equipment, and has several important applications in the field of medical instrumentation.

Atlas "Micro-Lite" lamps are designed for 1·2 or 1·5 volt operation, from 10 to 30 mA. For special purposes a 0·8 volt lamp is available with a current consumption of 6 to 8 mA. Due to the very low current consumption the "Micro-Lite" is suitable for transistor operation. Light output from the 1·2 volt lamp using a 10 mA supply is 50 milli-lumens.

There are four types:—A, B, C and D with overall lengths of 0·157 in., 0·137 in., 0·118 in. and 0·196 in. excluding leads.

Life expectancy for the Type A lamp at 1·2 volts a.c. is approximately 100 hours, but when operating on a d.c. supply, life expectancy is increased by 50%. Derated to 1 volt, a life in excess of 1,000 hours may be expected. Types A and B can be supplied with a cap and lampholder—the complete assembly having an approximate length of 0·431 in.

Circle **3** *for further details.*

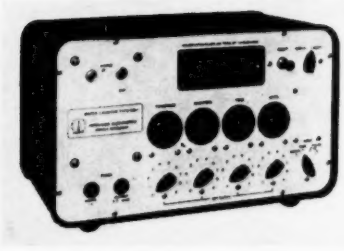
Packaged Computer Systems for Electric Power Generation Stations

A STANDARD computer system packaged for "off the shelf" sales to electric power generating stations is now available from International General Electric, a marketing subsidiary of U.S. General Electric.

Because the new system can be adapted for use in any power generating station with very little special programming, installation time can be reduced to less than 30 days.

The new computer is known as the GARDE system and is designed for monitoring, logging and processing of steam plant operational data in power stations. The system's designation was selected from an abbreviation of its functions: Gathers data, Alarms, Reports, Displays and Evaluates.

◀ *Transistor r.c. oscillator Type TG150D*



Batch counter Type CB11

Simplifix Type 60 gunmetal valve (off-set)

The GARDE system is designed around U.S. General Electric's fully transistorised 312 digital process control computer. It comprises the central computer with a 24,000-word drum memory (expandable to 52,000 words); operator's control panel; electric typewriters for logging data and preparing instructions; and a built-in programme for routine calculating and checking of turbo-generator operations.

During operation at a power generating station, the new system will gather data to central locations, compute hourly overall heat rate and component efficiencies, constantly check operating values for out-of-limit conditions, automatically prepare logs and automatically record values exceeding pre-set limits.

Circle **4** *for further details.*

Transistor R.C. Oscillators

LEVELL ELECTRONICS transistor r.c. oscillators Types TG150D and TG150DM give sine and square wave outputs over the frequency range 1·5 c/s to 150 kc/s. Type TG150DM differs from Type TG150D by the inclusion of an output meter.

The performance on sine waves and the mechanical details are as specified for the Type TG150 and TG150M sinusoidal oscillators.

The performance of the TG150D and TG150DM on square wave output is as follows.

Output:	Continuously variable up to 2·5 V peak source voltage at a source impedance which rises from zero to 600 ohms at maximum output. The square wave amplitude is directly proportional to the supply voltage.
Rise Time:	The time from 10% to 90% points is approximately 1% of the periodic time of the square wave, plus 0·2 microseconds.
Supply Current:	2 mA, more on square waves than on sine waves.

Circle **5** *for further details.*

Gunmetal Stop Valves

SIMPLIFIX Type 60 valves are now available in the following sizes, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 in. B.S.P. (female). All these valves are manufactured in gunmetal which gives good resistance to corrosion. The spindles are made from manganese bronze and have a fine thread which facilitates opening and closing. The spindle seal is inside the thread and so the medium in the valve does not come into contact with the thread. The valve tip is of nylon.

The port connections on this range of valves are suitable for Simplifix stud couplings which can be fitted as extras. Thus the valves are available for a very large range of pipe sizes.

These valves are designed for use in either pneumatic or hydraulic circuits or with non-corrosive gases. The following are the maximum working pressures:

	Hydraulic	*Gases*
$\frac{1}{4}$ in. in-line	1,000 lb/in²	200 lb/in²
$\frac{1}{2}$ in. in-line	600 lb/in²	150 lb/in²
$\frac{3}{4}$ in. off-set	400 lb/in²	100 lb/in²
1 in. off-set	250 lb/in²	100 lb/in²

All valves are individually tested to one and a half times the working pressure before they leave the works. They are not suitable for use with steam.

Circle **6** *for further details.*

Ferguson Electronic Batch Counter

AN electronic batch counter designed and built by Ferguson Electronics, will be marketed by the Industrial Control Systems Division of Thorn Electrical Industries.

The Ferguson batch counter has a counting speed of 4,000 per second and a batching rate of one per second. The unit is capable of counting 10,000 items in one batch up to a total of 1,000,000 batches. A total count of 10,000,000,000 may also be achieved by using the two counters in series. Batch sizes can be set easily and quickly by means of selectors on the front panel.

The unit is housed in a rugged steel case measuring $15\frac{1}{2} \times 10 \times 10$ in. and weighs 20 lb. It is designed to operate at 200—250 V (50 c/s) at an ambient temperature of 45°C maximum.

Dekatrons are used for the batching count and an electromechanical unit displays the number of batches.

External control of other systems is possible due to make or break relay contacts accessible at the rear. These may be connected internally to give a mains output which is initiated or stopped at the completion of counting.

Circle **7** *for further details.*

Disc Storage Unit

THE IBM 1301 random access disc storage unit holds up to 56 million characters of information and five of these units can be used with the IBM 1410 and 7000 series data processing systems giving a total storage of up to 280 million characters.

The IBM 1301 makes use of comb-like access arms flying on layers of air. Data, recorded in a pattern of 250 concentric tracks on magnetic discs, is read and written by these arms. This data can be transferred between the storage unit and the computer at a speed of up to 75,000 characters per second with the 1410 computer, or 90,000 characters per second with the 7000 series—speeds considerably in excess of magnetic tape units.

Previous random access storage units had from one to three access arms which serviced the whole file of magnetic discs by moving up and down from disc to disc as well as in and out from track to track.

The IBM 1301 has an access arm for each disc surface, and the entire "comb" of 40 arms moves in unison. There are 250 tracks on each surface and the discs of the IBM 1301 can therefore be thought of as a nest of 250 cylinders, each one holding up to 112,000 characters.

The cylinder concept means that data stored on discs will be arranged differently. Instead of storing it on adjacent discs to minimise vertical movement of the access arms, on the IBM 1301 data will be stored on the same or adjacent cylinders.

Access time within one cylinder is between 0 and 34 milliseconds and access time from one cylinder to another is between 50 and 180 milliseconds. Therefore the longest time that it can take to obtain any record in the whole storage of up to 280 million characters is 214 milliseconds.

Circle **8** *for further details.*

Excess Pressure Protection Valve

AN improved excess pressure protection valve for steam lines, which has a number of unique features, is being introduced by Sir W. H. Bailey & Co. Ltd. One of the most important single characteristics is that the steam supply is not shut off completely in an emergency, the downstream reduced pressure always being maintained at the set level so that process work, etc., is not interrupted.

The device includes a double-beat valve attached to a piston across which a pressure differential will be produced by any marked increase in inlet pressure. The effect of the differential is to lift the piston which brings the main valve closer to its seating faces, so that the downstream line is automatically protected from excess pressure. As soon as the supply pressure returns to normal, the valve automatically resumes its original position.

The incorporated relief valve, which is set to lift at a required safety pressure, will deal with any minor pressure rise, but a severe one will tend to close the main valve automatically, but still maintain a downstream supply at the pre-set reduced pressure.

The setting of the needle valve adjustment allows the performance characteristics of the valve to be matched to a specific application.

This device is available, initially, in bronze, with screwed ends, to fit pipe sizes $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and 2 in. It can be fitted into a line with a normal working steam pressure of 150 lb/in², but in an emergency an inlet pressure of up to 300 lb/in² can be accepted. The spring ranges available are 2-10, 10-80, and 80-150 lb/in².

Circle **9** *for further details.*

Versa Control Valves

To supplement the side ported range of valves, Versa have recently introduced a manifold mount range. They are available in 2, 3, 4 and 5 way types with over 20 actuating devices, in sizes from $\frac{1}{8}$ in. to 1 in. and for pressures from partial vacuum to 500 lb/in².

They can be mounted directly on equipment or a standard subplate as conditions dictate, eliminating complicated pipe layouts.

Actuating devices available are pilot, solenoid, hand lever, foot pedal, cam, differential pilot and diaphragm, various ones can be fitted with detent position selector, spring off set or spring centralising arrangements.

These control valves are available from British Arca Regulators Ltd.

Circle **10** *for further details.*

Signal Lamps

A NEW range of built-in disposable signal lamp units is to be marketed by the Special Products Division of Thorn Electrical Industries. Principle feature is simplicity of installation, the complete lamp unit is held in position in a 0·629 in. diameter hole by steel spring plates, so that no screws or retaining nuts are required. Each unit is supplied complete with a built-in neon or incandescent lamp. When effective life is ended, the complete unit may be discarded and a new one inserted.

Three basic types are available, as follows:

1. The SGF 1717. This unit has been designed to operate in conditions of heat or extreme cold, effectively resisting temperatures as high as 135°C, and is therefore suitable for heating equipment applications such as electric cookers, frying ovens, heat treatment plant, etc. The SGF 1717 measures 1·377 in. long and is available in a wide range of lamp colours. The incandescent version is available for 110, 220, or 380 volt operation. Life expectancy of the incandescent version is 5,000 hours.

2. The Type SGF 20 signal lamp is designed to operate in temperatures up to 125°C, the incandescent version being available for 4, 6, 12, 24, 36 and 48 volt operation, and the neon version for 110, 220 and 380 volt operation.

3. The SGF 16 is identical in size and appearance to the SGF 20 but is supplied with a neon lamp only and is designed to operate in temperatures up to 70°C. It is available for 110, 220, 500 volt operation.

Circle **11** *for further details.*

Circle 352 for further information

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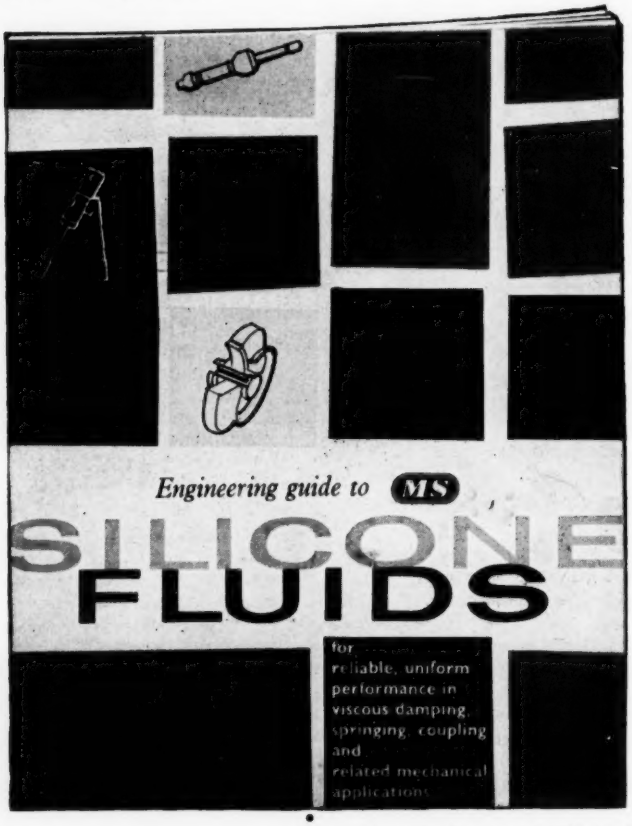
If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G 14) *is the publication for you.*



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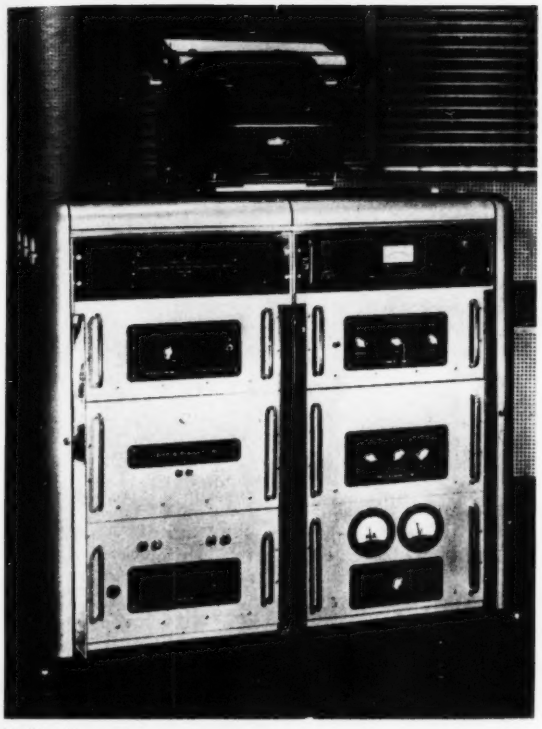


Radio-chromatogram scanner

Radio-chromatogram Scanner

GAUGING SYSTEMS LTD. have, in conjunction with Beechams Research Laboratories Ltd., developed a two-dimensional radio-chromatogram scanner. Continental Distributors have been appointed sole sales agents for this instrument.

The scanner makes quantitative evaluation of bidimensional radio-chromatograms using beta-emitters such as C^{14}, P^{32}, S^{35}. Accuracy is better than 1%.

The radio-chromatogram is taped to the print-out paper inserted into the electric print-out machine which carries out the actual scanning by moving the chromatogram between the two end window G.M. tubes.

All counts are reduced to a four figure print-out. The scanning period is variable at will up to 999 seconds.

If the counts are below the preset threshold (up to 99) the programme unit allows the scanning to be carried out in much less time than the actual preset scanning time, and the print-out is in black; unit areas with counts above threshold are allowed to be scanned for the full pre-set time period and the print-out is in red.

The counts are passed to the scaler from the programme unit and after the scanning period, read-out and print are initiated.

Automatic self checking is introduced as the last count on each line, from a standard frequency source.

The actual number of lines scanned is pre-set on a line counter which automatically switches off the whole instrument after this number of lines has been scanned. The print-out machine is an Addo-X 6000 model allowing chromatograms 17 × 19 in. to be scanned.

Circle **12** *for further details.*

Base Pressure and Volume Indexes for High Pressure Gas Meters

Now available from Parkinson Cowan Gas Meters are a base pressure index and a base volume index for use with high pressure gas meters. These indexes completely eliminate the need for the complicated calculations hitherto associated with the accurate measurement of gas at high pressures.

Briefly, the base pressure index automatically compensates for the gas pressure by mechanically multiplying the volume of gas by the pressure factor and registers the amount of gas at base pressure which has passed through the meter.

The base volume index performs an identical task but also compensates for temperature.

A supplementary volume and pressure gauge is available for use with both instruments. This gauge plots on a chart the time and pressure at which each thousand cubic feet of gas passes through the meter, thereby providing a permanent record for analysis and reference purposes.

Circle **13** *for further details.*

1 in. Scale Instrument Range

A WHOLE series of edgewise measuring instruments, either on the vertical or horizontal plane with a 1 in. scale have just been brought out by Measuring Instruments (Pullin) Ltd. They are the smallest in their range and measure 1 19/32 × 1¼ in. with a back depth of just under 2 in. weighing some 2½ oz. These miniature instruments are strong, and are housed in a phenolic resin case which is proof against dust and water splashes. A special feature is the simple means of panel fixing for easy installation. Available either for measuring amperes or volts, there are various ranges from 50 μA to 500 mA and voltages up to 250 V. For higher ranges external shunts or multipliers can be used.

Circle **14** *for further details.*

Weight Trip Amplifier for Cranes

ACCURATE indication of the approach or attainment of the maximum safe load on a crane is provided for the operator by the new Ekco Type N684 weight trip amplifier. A fully-transistorised instrument, it utilises the normal 12-volt supply fitted to the crane and draws very little current. The many applications of this equipment include mobile and static cranes, fork-lift trucks, etc.

There are two main systems. The first provides an amber lamp signal at the pre-set safe-load and two further lamp signals at a pre-determined percentage deviation below and above the safe-load respectively. The second system provides a red signal lamp indication when the safe-load limit is reached, in addition to continuous meter indication of actual safe-load percentage. Provision is made in both systems for operation of an audible alarm.

The Type N684 has a safe-load alarm accuracy of

± 0·5% and a deviation alarm accuracy of ± 2½% of setting, over a temperature range of −10 to +40°C. The amplifier circuits are designed to provide a red alarm in the event of any part of the internal circuit failing, while a green lamp indicates that the battery supply is connected.

The complete equipment consists of three main units—the load cell, main amplifier and indicator unit. The load cell comprises a specially bonded pressure-sensitive resistor element and is installed at a suitable strain point on the crane. The main amplifier is housed in a strong, weather-proof case and incorporates the trip set controls, while the weatherproof indicator unit is positioned in the most convenient position for the crane operator.

Circle **15** *for further details.*

Air Cylinder

AIR AUTOMATION have recently introduced a new ½ in. bore air cylinder with rectangular section brass body and ⅛ in. BSP ports. This is available in stroke lengths of ½ in. to 1½ in. and in single acting, double acting, and single acting spring return models.

This cylinder is provided with screwed nose mounting and also with fixing holes through the body to provide for side or base mounting, and with provision for rear trunnion mounting, all as standard.

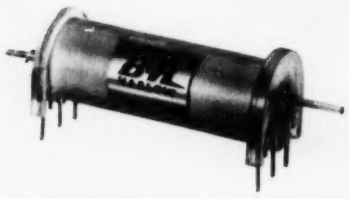
The piston rod is of stainless steel and the rod and piston seals are neoprene distributor type "U" seals, no "O" rings being used in the cylinder which is therefore capable of operating at fast speeds under light operating pressure and with a minimum of stiction.

A midget flow control valve No. A70M is available for the speed control of these cylinders.

Circle **16** *for further details.*

Dry Reed Relay for Printed Circuits

MOUNTED on a nylon bobbin and measuring only 1 in. in diameter by 2 in. long, less reed ends, B.&R. Relays' latest dry reed relay Type R.03 weighs approximately 2 oz. It has been designed for printed circuit application, and is fitted with six standard contact prongs. The relay contains one normally open reed. Coils may be



Dry reed relay

specified to requirements with resistances up to 20 k ohms, and while a nominal power of 0·06 watts is required, the relay will operate efficiently at 0·048 watts. As with previous dry reed relays in the B. & R. range, the R.03 is d.c. operated and has a similarly high life expectancy (20×10^6 operations at maximum contact rating) and a contact resistance of 0·030 ohms.

Circle **17** *for further details.*

The Productograph

THE "Productograph", for which Adrema Ltd. have the marketing and assembly rights for Great Britain from Siemens-Halske, Germany, is a system for the recording and writing of full production data from individual operating units in a production process.

Essentially, information is gained via transducers and converted into an electrical signal, which is then fed to the "Productograph" control centre.

The "Productograph" control centre, which may deal with 20, 40, 60, 100, or 200, transducer sources of information, consists of several units.

There are: the linear counter for the visual production recording of each unit in the workshop or factory; the electrical counters, which record the quantity of product produced and the production time consumed; the integrator for group control, which indicates, by a light system, the productive and idle times of plant units; the machine diagram recorder, which records continuously the production cycles of up to 20 machines per recording unit on 20 double tracks on inkless, waxed paper; the high-speed recorder for the extended work analysis of any particular production unit; the duplex and light signalling installation for control lights at plant stations and for two-way communication between the operator and control; and the tape recording system for the recording of instructions and advice, explanations, etc., from night-shift operators when the "Productograph" may be left unattended.

The Linear Counter. The production process is optically reproduced. Two film tapes pass behind a scale having 30 units of 10. The blue tape shows the actual state of production. The yellow tape is pre-set to show the required amount of production. By means of a decade plug, each unit can represent ten, 100, or 1,000 production units according to the type of product. When the blue meets the yellow tape a green overlap occurs, which instantly shows that the required amount of production has been reached. This state can also be automatically signalled to the plant operator, who may then transfer to other production. Each linear counter console has 20 production lines, thus enabling the supervisor or production manager to have a co-ordinated view of a workshop or a section of it.

The Counter System. By means of six-digit counters adjacent to each tape counter system, such data as the machine production times and total idling time can be seen at any moment. On the main "Productograph" console there is an integrated unit of six counters, which indicates the integrated machine operating times, the total idle time causes for up to 200 machines, etc. Any machine can be excluded by simple means.

The Integrator for Group Control. This is a lamp panel illuminated so as to give an instantaneous overall view of the operation of each production unit at any given time. At one glance it can be seen what machines are operating or idle because of setting up, breakdown, tool breakage, lack of material and so forth.

The Machine Diagram Recorder, or the "Productograph" Diagram is the heart of the "Productograph" system. The impulses from the transducers here operate two needles and the diagram recorder takes up

to 20 machines per unit. One needle scratches on a special waxed moving paper a linear diagram showing the actual operating and standstill times of the machine. The lower indicates under the line causes for standstill, production speed (number of articles actual in units, tens or hundreds). The reasons, up to five for standstill causes, are conveyed to the recorder by the machine operator pressing a button on the key-operated interruption switch at his work station. The recorder moves at half-a-millimetre per minute. The recorder simplifies the work study approach to assembly or production line or workshop or plant. Fatigue time experienced by operators is easily discovered.

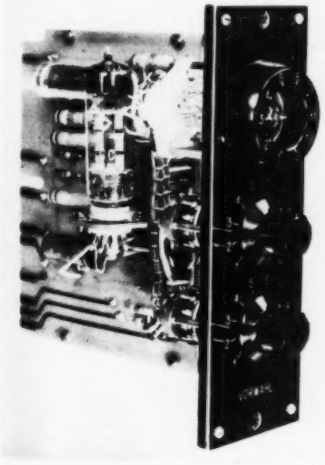
When a detailed analysis of a particular machine, such as when dealing with a new method or product, is required, the high speed recorder which records one machine on a single strip moving at 30 millimetres per minute is used. It is excellent for operating analyses and may be connected with any machine by the pressing of the requisite button. Even where processes follow one another in rapid succession, all the irregularities can be clearly observed.

Key-Operated Interruption Switch. This switch is mounted at the operator's station or machine. When his work is interrupted for any cause, the operator presses the requisite button keyed to that cause. A warning light comes on when the transducer on the machine indicates an interruption to production, which is also indicated at the "Productograph". Thus the operator is reminded to press the appropriate key. When production starts the transducer signal will automatically release the pressed key back to normal.

The Telecommunications System is installed on the "Productograph" console. This enables communication to be made with the machine operator, and through desk extensions to production managers, works manager, foreman, supervisor stores, and others.

The "Productograph" system enables operations to be supervised simultaneously and for data to be obtained and recorded instantaneously.

Circle **18** *for further details.*



Electronic counter with dual reset stage

Electronic Counter

THE ELESTA electronic counter IZ.301, available from Britec Ltd., incorporates the decade counter-selector tubes Type EZ. 10B and has a maximum counting rate of 500,000 p.p.s.

It is supplied as a complete instrument only, with its power supply unit and several printed-circuit plug-in sub-units. Two models are available, one with up to six sub-units and the other with up to eight sub-units, which consist of various input, coupling and output stages to suit any requirement. A range of decade stages is offered, with single or dual reset circuits, for batching any pre-determined number up to 100,000 per second; this is effected by pre-setting the pointers to a number corresponding to the difference between the maximum capacity of the counter and the number to be counted; when the counter reaches its final position the output stage is triggered and the counter is reset. A high-sensitivity universal pre-amplifier for various inputs is also available, as well as a 100 kc/s crystal-controlled frequency oscillator stage and a universal output stage with a coincidence circuit and an output relay. The counter can be directly operated from germanium photo-diode, pulse or contact inputs.

Operating voltage:	220 V a.c. ± 10%, 50 c/s.
Consumption:	50 VA max., with 8 stages.
Finish:	Grey stove-enamelled metal housing with black plastic panels.

Circle **19** *for further details.*

Polystyrene Capacitors

A NEW range of close-tolerance polystyrene capacitors is announced by the Capacitors and Resistors Division, The Plessey Co. Ltd.

Standard unprotected polystyrene capacitors are normally restricted to an upper temperature limit of about 70°C because of the risk of deformation as the softening temperature is approached. Encapsulation of the capacitors reduces the risk of deformation and the rated temperature limit can be raised to 85°C.

Capacitance range in the new series is 10 pF to 0·22 μF. Higher values up to 0·5 μF are available as non-encapsulated types and a range of aluminium cased types covering the higher capacitance values is also being marketed.

Working voltages for encapsulated and unprotected types are 125, 350, 500, 750, 1,000 V. Encapsulated types are also available for operation at 2,000 V.

High insulation resistance and low power factor are important characteristics of polystyrene capacitors and typical values for units in the new Plessey range are 10^6 megohms and 0·005 respectively.

Circle **20** *for further details.*

Aluminium Air Plug Gauges

TEDDINGTON INDUSTRIAL EQUIPMENT LTD. have introduced a new type of air plug gauge, known as Hardcoat plugs.

These are made of aluminium specially processed to have a very hard surface. This together with a large wear allowance gives Hardcoat plugs a tough thick wear surface ensuring a long life.

Through and blind hole forms are available for all sizes larger than 0·400 in. and for holes of any depth.

Circle **21** *for further details.*

"Sealectoboards" with Semi-automatic Programming

PRE-PUNCHABLE masks are the latest introduction to the "Sealectoboard" system of cordless programming. Fabricated from thin, tough, dimensionally stable material, the masks are furnished to register with any size or style of "Sealectoboard".

In operation, the programme is set up on the patching-mask by punching holes where pins are to be plugged—a spring type punch is available to facilitate this pre-programming—the actual patching can then be performed by unskilled operators with the minimum error hazard.

A matt surface on the masks permits the recording of programme details. They can also serve as programme storage because they can be filed for further use.

Circle **22** *for further details.*

Portable Hardness Tester

THE Newage portable tester has a pre-loaded (7·5 kg) diamond indentor. To make a test the hand-grips are pressed toward the specimen. During impression the resistance of the specimen to deformation causes the penetrating mechanism to compress a chamber of fluid by means of a metal diaphragm hydraulically forcing fluid into a capillary tube under the dial. The final position of the fluid indicates the direct hardness value. The loading mechanism is designed so as to be friction-less yet free from side thrust inherent in conventional light load instruments. The patented pre-loaded assembly is designed to prevent variable pressures exerted by individual users from affecting the accuracy of the instrument. Each tester is calibrated to a single range:

Rockwell "A" range 35-75 scale
Rockwell "B" range 5-100 scale
Rockwell "C" range 10-70 scale
Rockwell "15" range 70-95 scale
Brinell medium range 100-440 scale
Brinell low range 50-260 scale.

The tester weighs 30 oz. With it direct readings can be obtained quickly, without cutting a sample or damaging the work. Results are obtainable immediately from the dial reading.

The entire hardness scale of each tester is matched to a complete range of master Rockwell or Brinell blocks by means of hand calibration. All portions of the hardness scale are verified against these blocks ensuring accuracy of ±5 points on the Brinell dial.

This hardness tester is available in this country through Metallurgical Services Ltd.

Circle **23** *for further details.*

Germanium Transistor

RCA have available the 2N404-A germanium p-n-p alloy-junction transistor for switching applications in military and industrial data-processing equipment.

Collector-to-base voltage rating −40 volts
Collector-to-emitter voltage rating −35 volts
Emitter-to-base voltage rating −25 volts
Collector-current rating −150 mA
Emitter-current rating 150 mA

Circle **24** *for further details.*

Improvements to Tramp Iron Extractors

RAPID MAGNETIC LTD. have introduced means of avoiding premature release (due to supply failure) of tramp iron extracted by electro-suspension magnets. Auxiliary built-in permanent magnets retain the collected iron until the holding force is neutralised by operating the contactor controller and reversing the current.

The technique can be applied to any of the wide range of circular, square or rectangular suspension magnets produced by Rapid.

Circle **25** *for further details.*

Universal C-tan δ Bridge

SIEMENS AND HALSKE have developed the C-tan δ bridge for measuring capacitance and loss factor at power frequencies.

It is intended for testing capacitors, cables, ating machines, transformers, transmission lines, etc. It is also useful for investigating the properties of insulating materials, porcelain, mica, plastics, impregnating varnishes and oils at various temperatures, since other characteristics of such materials can be deduced from their dielectric behaviour. Automatic balancing of the bridge is possible, whereby the loss factor, relative change in capacitance and crest voltage can be continuously recorded.

The bridge operates at two power frequencies, and has recording facilities for crest voltage, loss angle and $\frac{\triangle C}{C}$ and digital print-out facility in special cases.

The range of measurement for capacitance is from 10 pF to 2,000 μF at charging currents up to 30 A (100 A and 1,000 A with shunts). The voltage range is $_r$ to 800 kV.

The instrument is available through R. H. Cole (Overseas) Ltd.

Circle **26** *for further details.*

Daylight-operated Switch

A SMALL automatic daylight-operated switch, designed to control shop, factory and street lighting, signs and shop blinds without attention, is now being manufactured by Hird-Brown Ltd.

The switch incorporates a photo-conductive cell of the cadmium sulphide type which is manufactured by National Semiconductors Ltd., of Montreal, Canada, for whom Hird-Brown are the sole agents in the United Kingdom.

The case of the switch measures 6 × 3 × 2 in. and it can be drilled and fitted in any position. It is simple to connect up and can be set to switch on and off at any level of daylight. It is suitable for all climates and is fully compensated for variations in temperature.

The switch operates on 100/110 or 200/250 volts, a.c., single phase, 50/60 cycles, and incorporates a time delay so that it is not affected by short term light changes.

Marketed as the NCS unit, its price is £9 15s. 0d.

Also produced by Hird-Brown Ltd. is the N2CS unit which has two photo-conductive cells, each independent so that the switch-on point can be quite different from the switch-off point. Its price is £15 10s. 0d.

Circle **27** *for further details.*

Canteen Catering

As in every other industry, the main factors governing the economics of the catering business are: quality of product, cost of production, and well-being of workpeople. Electricity measures up well to these three essential factors.

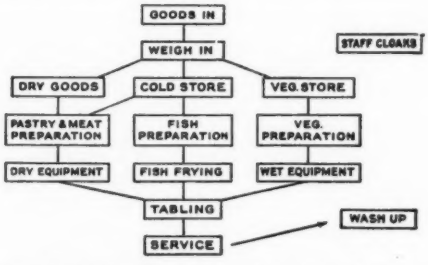
The outstanding virtue of electricity is better cooking, particularly in roasting and pastry ovens where high quality is more easily maintained than in ovens using other forms of heat. The cost of production varies somewhat with the type of food and the size of the establishment, but is usually between ½ and ¾ of a unit of electricity per meal. Cleanliness of electric cooking is axiomatic and provides better working conditions for the staff.

The actual size of the kitchen is influenced greatly by its shape and by the number of people catered for, but a rough guide is as follows:

KITCHEN TO DEAL WITH		SIZE
up to	100 persons	5-6 sq. ft. per person
	100-250 persons	4-5 sq. ft. per person
	250-1000 persons	3-4 sq. ft. per person
over	1000 persons	3 sq. ft. per person

Design

Where the kitchen is designed from the start for the full use of electricity, planning is simplified as the equipment can be placed where it is required without reference to the need for flues.

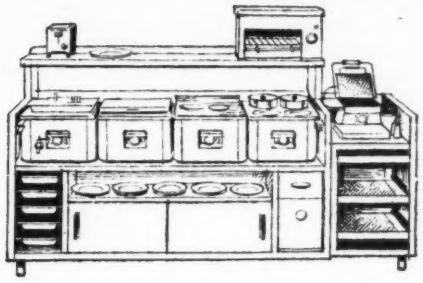


If an existing kitchen is already using other types of cooking equipment, however, electrical equipment can still be introduced item by item to bring increasing benefits.

Quick-service Equipment

The popularity of the quick-service establishment where the food is cooked at the service counter in the full view of the customer is steadily growing, and this type of catering can readily be provided in the canteen by the installation of a Back Bar cooking unit, installed behind a section of the service counter.

The popularity of the mid-day joint and two vegetables is on the wane and the really up-to-date

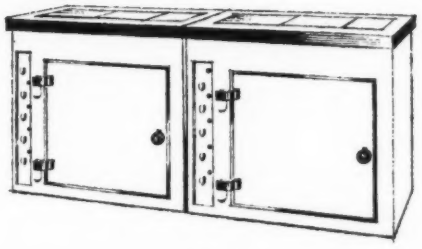


canteen should provide the welcome alternative of fresh food cooked on the spot.

Electric Catering Equipment

Electric catering equipment covers every single kitchen activity and some of the appliances in common use are:

COOKING. Ranges, boiling tables, steaming, roasting and pastry ovens, vegetable boilers, fryers, griller/toasters.



SERVICE AND WASHING-UP EQUIPMENT. Bains-marie, hot cupboards, tea and coffee machines, washing-up machines for the larger kitchen and sterilising sinks for the smaller, refrigerated cold-service counter and display cabinets, soda fountains.

PREPARATION. Mixing machines with attachments for chopping and mincing etc., potato peeler, slicing machine.

QUICK-SERVICE EQUIPMENT. Infra-red (contact) grill, automatic toaster, griddle plate, automatic fryer, boiling plates, soup heaters, etc., and, of course, the indispensable refrigerator.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on the industrial and commercial uses of electricity and reprints of articles and papers are available.

E.D.A. have available on free loan in the U.K. a series of films on the industrial uses of electricity. Film and Book Catalogues and Publications List sent on request.

12799

Complex Ratio Bridges

Now available from The Wayne Kerr Laboratories Ltd. are two complex ratio bridges, the CRB-1B and CRB-2B, for precise measurements of in-phase and quadrature voltage ratios of three and four terminal networks such as transformers, synchros, resolvers, gyros and transducers. The instruments also measure the phase shift angle between 0 and 1° or 0 and 10°, and the tangent of the phase shift angle.

Having an accuracy of 0·001%, six-place resolution and needing no external calibration sources, the new bridges operate over the frequency ranges 30-1000 c/s (CRB-1B) and 50-3000 c/s (CRB-2B). Readout of the transformation ratios is directly from digital switches and is in terms of rectangular coordinates, tangent, or phase angle between the voltages involved, i.e., the phase shift present between the primary and secondary voltages of the device under test.

The basic circuit for the measurement of a.c. voltage ratios is the same in both instruments: a Gertsch ratio transformer functions as the ratio arms of an a.c. bridge and the off-null voltage obtained during the balancing operation is fed to a high gain (×500) amplifier. The amplifier gives a detector circuit which enables very small values of off-null voltages to be quickly detected, the sensitivity of the null detector being 10 microvolts.

Other features of the circuit eliminate the effects of harmonic voltages, noise and quadrature voltages caused by phase shifts across the device being tested. Phase-reversal switches for both in-phase and quadrature voltages allow measurements to be made, without loss of accuracy, in any quadrant.

Both instruments have a power input rating of 100 watts at 115-230 volts, 50-60 c/s and both are provided with current and voltage terminals to eliminate errors caused by i.r. drops in connecting leads when the unit to be tested draws heavy current.

Size of the equipment when supplied in cabinet form is $19\frac{1}{2} \times 16\frac{1}{2} \times 13$ in; for rack mounting, the dimensions are $19 \times 14 \times 12$ in.

Circle **28** *for further details.*

Tape Verifier

The expanding use of 6- and 7-track punched paper tape in the computing and data processing industry has created a need for a tape verifier capable of handling these expanded codes. A new version of the Creed Model 90 tape verifier meets this need and is available for 5-, 6- or 7-track tape verification.

Designed specifically for data processing applications, the Model 90 provides means for automatically detecting and eliminating operator errors in the punching of 5-, 6- or 7-track tapes at speeds up to 15 characters per second.

The verifier consists of four separate inter-connected units of Creed punched tape equipment: a Model S4136 multi-wire keyboard, a Model 92 tape reader, a Model 25 tape punch and a power pack.

Operation of the verifier is based on the automatic comparison of two separate transcriptions of the same source data. The unverified tape is fed into the tape reader and the data typed out a second time from the source document. The units are electrically interconnected in such a way that when the code produced by the second typing agrees with that already punched in the original tape, the same character is punched in a second tape.

When the two codes do not agree, the keyboard locks and nothing is punched on the second tape. After determining whether the error was in the first or second typing the operator takes appropriate action so that the correct character is punched in the second or verified tape.

Another new version of the Model 90 is the verifier-reproducer set which incorporates a Creed Model Seventy-five teleprinter with tape punch attachment in place of the Model 25 tape punch. This further extends the versatility of the equipment by adding page printing, tape editing and tape interpreting facilities to its existing capabilities.

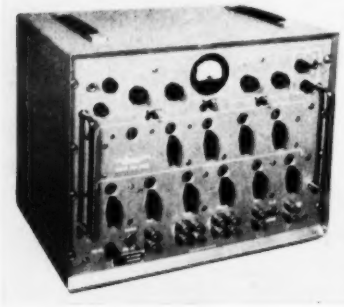
The keyboard unit of the verifier-reproducer is of a new design and incorporates a number of new features. One of these is a special high speed " skip " facility which enables the operator to make the tape reader pass over any redundant data and stop at the first character after the unwanted characters. Another feature is the inclusion of warning lamps which give the operator a constant indication of the parity or disparity of the character being verified.

Now in full production, the new Creed Model 90 verifier is priced between £513 and £663 (according to tape codes required) while the new verifier-reproducer set sells at £1,200.

Circle **29** *for further details.*

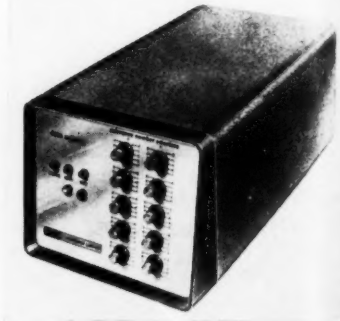
Data Selector Unit

The data selector Type UE875 from Ultra Electronics Ltd. enables blocks of information encoded on paper

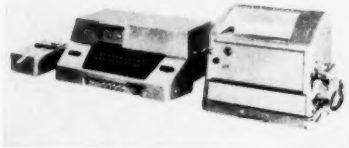


Complex ratio bridge

Data selector Type UE875



Model 90 *verifier-reproducer set*



tape, magnetic tape or punched cards to be selected and routed to any one of up to 10 output channels.

Up to 64 lines are available on each output channel—sufficient to operate a full typewriter keyboard. The output channels will also operate add/list machines, paper tape punches, etc. One simple application of the facilities provided by this unit is in 10-way sorting operations.

Selection of data is achieved by inserting selection characters between successive blocks of information fed into the unit. Up to 99 such selection characters are available. The information required for any particular output channel is selected by the appropriate code selection switch on the front panel. The input signals are decoded by a matrix mounted on slide-in printed circuit boards which can be in combinations to accommodate any 5, 6, 7, or 8-hole code. Most types of paper tape, punched card and magnetic tape readers are suitable as input sources.

Circle **30** *for further details.*

High Voltage Medium Power Silicon Diodes

Two new ranges of high voltage medium power silicon diodes are available from Westinghouse Brake and Signal Co. Ltd. The SxBR8 is rated at 18 amperes and may be used at case temperatures up to 140°C, whilst the SxBR25 is rated at 30 amperes and may be used at similar case temperatures. Both ranges are freely available in voltage ratings of 100 to 1,500 volts peak, with ten intermediate voltages.

The diodes are hermetically sealed using glass/metal seals. Mounting is by means of a stud base which also serves as the anode connection. The cathode connection is made by means of an insulated flexible lead through the glass/metal seal.

Circle **31** *for further details.*

Oscilloscope

THE Aveley Electric Ltd. Du Mont Type 403-B oscilloscope has a sensitivity of 50 microvolts per cm, with low noise level to permit resolution of signals as low as 10 μV.

Sensitivity of the Du Mont 403-B permits display of non-amplified outputs from most strain gages, pressure pick-ups, accelerometers, and other transducers. Its range of sweeps extends the instrument's usefulness to encompass almost any recurring phenomenon or transient. Its 21 calibrated sweeps extend from 1 μsec/cm to 5 sec/cm with a vernier providing continuous adjustment between steps—and extends the 5 sec/cm range to slower than 25 sec/cm for a 250 second maximum sweep duration. A single sweep mode permits but one driven sweep of the time base to appear on the cathode-ray tube until the sweep is reset. An available accessory kit (Type 4001) allows the user to control the sweep from external switch closures such as those built into the synchro shutter of the Du Mont 450 oscilloscope record camera and found on cams and other rotating machinery.

Other main features of the 403-B oscilloscope include a nominal drift of less than 500 μV/h after warm-up, an a.c. stabilising control that virtually eliminates d.c. drift, a sync ready indicator for indicating optimum trigger adjustments, and a 5 kV c.r.t. with a P31 phosphor is normally supplied. P1, P2, P7, or P11 phosphors are available, as well as a metallised screen for maximum light output.

The Y attenuator permits balanced operation on each of its 17 positions. Common mode rejection is better than 120 to one.

Circle **32** *for further details.*

Elapsed Time Indicator

LEYLAND AIRBORNE PRODUCTS DIVISION of AMF has introduced an elapsed time indicator known as the time totaliser.

The device will be of prime value for the preventive maintenance of electronic gear both ground and airborne.

Other uses, besides replacement calculations, include: timing of devices within a warranty period; timing of the use of rented equipment and machinery; timing of machinery and parts for preventive maintenance; timing of devices which are used intermittently and life tests of machinery, parts and devices.

Functionally, the time totaliser is a mercury coulometer, operated by an integral electrical network which compensates for temperature differences and for supply voltage variations. Two basic models are available for either a.c. or d.c. operations. At the present time both models are designed for full scale ranges of 1,000 hours.

Voltage Source:	A.C. version, 105 to 125 volts and 200 to 250 volts with a frequency range of 50 to 2,400 cycles per second; d.c. version, 24 to 32 volts
Power Consumed:	0·5 watts (approximately)
Compensated Temperature Range:	From −35°C (−30°F) to +71°C (160°F)
Accuracy:	± 6% over full temperature, voltage and frequency range
Physical Dimensions	1 × 9/16 × 2-3/16 in. Volume, 1·23 in³ Weight 1·2 oz
Connections:	Screw terminals
Protection:	Clear plastic housing, hermetically sealed against moisture and dust
Shock Resistance:	From 10 to 500 *G*
Vibration Resistance:	Up to 500 cycles per second at 10 *G*
Price:	£10 (approximately)

Circle **33** *for further details.*

Transistor Clips

JERMYN INDUSTRIES have extended their range of transistor clips to include the JEDEC TO-5 and JEDEC TO-18.

They also have available a smaller version of the Sistaclip designed to accommodate the Ferranti diode 7,510A, i.e. diameters from 0·189 to 0·250 in. Other diameters which can be accommodated are 0·305 to 0·358 in. and 0·150 to 0·200 in.

A sub-miniature valve clip which will hold valves nominally 0·4 in. diameter is also obtainable.

Circle **34** *for further details.*

Vacuum Thermocouples

R.M.S. measurements at frequencies from below 0·1 c/s to several hundreds Mc/s are now possible using vacuum thermocouples manufactured by Best Electrics Ltd. Three different patterns of thermocouples cover this frequency range:

Long time constant pattern:	0·1 c/s—25 c/s
Standard pattern:	25 c/s—65 Mc/s
U.H.F. pattern:	65 Mc/s and higher

If, by measuring the thermo-electric e.m.f. on a suitable millivoltmeter, the thermocouple is calibrated on d.c., then the same calibrations will hold, within very close limits, on a.c. Further, since the output of the vacuum thermocouple is dependent on the heating effect of the current being measured, r.m.s. readings are indicated over a wide range of frequencies regardless of waveform.

A comprehensive range of high grade vacuum thermocouples, with current ratings ranging from 1 mA to 1000 mA and beyond, are manufactured by Best Electrics Ltd. In addition Best Electrics Ltd. are licensed to manufacture compensated vacuo-junctions as developed by The National Physical Laboratory, in which divergence from a truly square law response is reduced to low level.

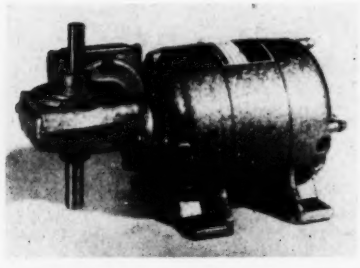
Circle **35** *for further details.*

Fractional Horse-power Motors

COMTEX LTD.'s new range of fractional horse-power motors are manufactured to class "E" BS 2757 (which allows a temperature-rise of 65° above ambient), they are known as the GL8 (motor only), GL9 (motor with single reduction gearbox), and GL10 (motor with double-reduction gearbox). They are available for single and three-phase supplies and for various voltages thus:

1/30 hp at 1400 rev/min (nominal) 50 or 60 c/s, single phase 100/110 volt.

200/220 volt, 230/250 volt, and three-phase 400/440 volt.



F.H.P. motors

All motors, both induction and commutator type, are supplied as standard reversing, and at no extra cost a new design of capacitor can be fitted to the rear end of these motors to make compact, self-contained units—or alternatively the capacitor can be separately mounted in the usual way. They are easily mounted by foot or flange, and are suitable for running in any position, base holes being elongated for final adjustments. The gearboxes can be turned to bring the output shaft into a variety of positions to suit the job on hand, and practically any final output speed can be supplied.

Encapsulated windings will be available in addition to the normal class "E" BS 2757, rendering them impervious to attack by moisture, oil, and most chemicals. Thus, an open drip-proof motor encapsulated in this way can often be used in place of a totally enclosed frame, obviating the need for a larger unit.

Each unit is tested electrically and mechanically at every stage of manufacture and carries a 12 month guarantee. All the rotating parts are statically and dynamically balanced electronically, using the most up-to-date machine specially developed for this purpose. Basically, this machine gives an output signal, amplifies and feeds it to a meter indicating the amount of imbalance, the angular position of this imbalance being indicated by a stroboscopic lamp.

Circle **36** *for further details.*

Insulation Tester

THE Model 130C insulation tester from Taylor Electrical Instruments Ltd. covers a wide range of resistance readings and enables tests to be made on all types of components including resistors, condensers, switches, transformers, motors, elements, domestic appliances, general writing, circuits, continuity, etc. Total resistance measurements covered are from 20 ohms to 1,000 megohms and for insulation measurements a test voltage of 500 V d.c. at infinity is applied to the component under test via a safety push button switch.

Measurements are made on a 5 in. scale. The meter movement is of centre pole design with a sensitivity of 37·3 μA. The movement is very robust and has sprung jewels to withstand rough handling. The centre pole meter is also magnetically shielded and this is an important feature when using the instrument in the proximity of r.f. fields. Model 130C is supplied in a rugged bakelite moulding.

The Model 130C is designed to operate from an a.c. mains supply between 110 V and 240 V, 40-60 c/s. The primary of the mains transformer is fused and the mains adjustment panel and fuse holder are readily accessible.

Circle **37** *for further details.*

Subminiature Glass Zener Diode

FOR printed circuit boards, miniature circuitry and other applications where miniaturisation is paramount, subminiature glass Zener diodes with wide voltage range (3·3 to 27 volts) and rated at 250 milliwatts power dissipation are now available from International Rectifier Company (Great Britain) Ltd. High stability and excellent voltage regulation over the temperature range from −55 to + 150°C is provided by this new series.

Designated types QZ3·3 to QZ27, units are available in both 5% and 10% voltage tolerance types, tolerance being specified by adding T10 or T5 to the type number, and have a maximum Zener impedance range from 5 to 70 ohms.

All units feature glass-to-metal hermetic sealing for ruggedness and optimum reliability, and measure 0·265 × 0·110 (dia.) inches, not counting leads.

Prices for 1 to 49 off:

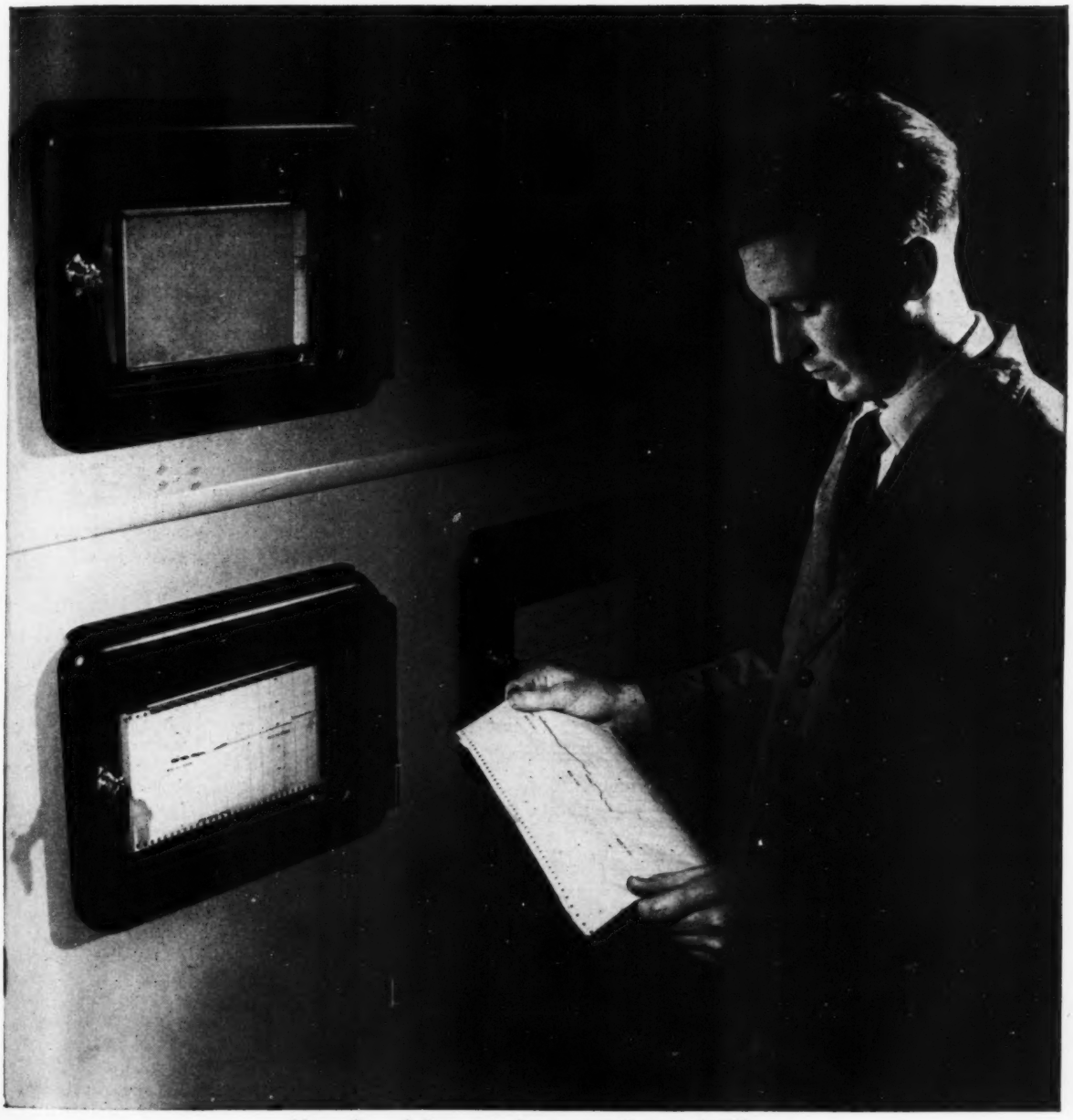
T10	8s. 6d. each
T5	9s. 3d. each

Circle **38** *for further details.*

Circle 354 for further information

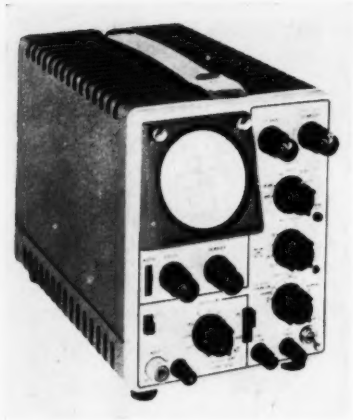
He reads it easily...

A clear record of the last two shifts—and the pen already beginning its course on the next chart. In his hand he has the past: on the panel is the present. Arkon Recorders measure gas, air, water and effluent flow, pressure or vacuum, or pressure and vacuum; flows in one inch pipe or 36 inch mains, pressures from 0.1 inches water gauge to 500 lb. per square inch. They give a clear, unmistakable record which you can read like a book, without hesitation and without mistakes. You can leave the chart on for a few hours, a day, or a week—the record will always be there. Easily read, easy to look after, robust enough to stand on the job, Arkon Instruments can help the control of any process—and their accuracy will satisfy even the men in the lab.

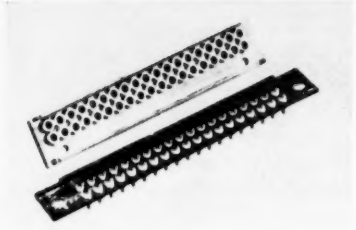


More about Arkon recorders in our illustrated leaflet

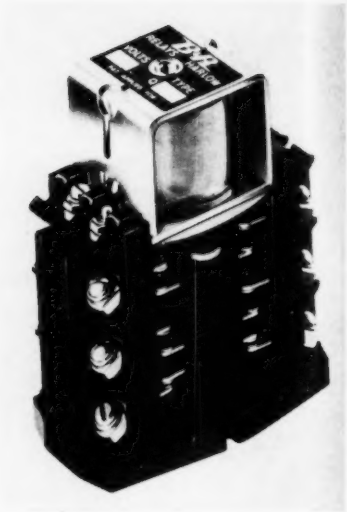
WALKER CROSWELLER & CO. LTD · CHELTENHAM · Tel: Cheltenham 56317



Serviscope Model S32



Rack and panel connector components



Contactor relay Q.51/3 ▶

Serviscope Oscilloscope

MODELS S32 and D33 are the latest additions to the Telequipment range of Serviscopes. S32 is a high performance development of Model S31, which it replaces. D33 with its alternative plug-in amplifier is a light, portable, high performance instrument capable of tackling a wide range of applications.

A new feature of the D33 is a high voltage (3,500) p.d.a. tube. Accessories include a high impedance $\times 10$ divider probe, camera attachment and extendible light hood.

A similar p.d.a. tube is incorporated in Model S32 which weighs 16 lb. Fast rise time and an extremely efficient triggering device are allied to a bandwidth increase to 7·5 Mc/s at 100 mV/cm and a high gain position providing 10 mV/cm, d.c. to 200 kc/s. The S32, which will operate from a 110 or 200/250 V supply, costs £78.

Circle **39** *for further details.*

Rack and Panel Connector Components

COMPONENTS permitting " do-it-yourself " design and assembly of multi-point rack and panel connectors, eliminating the need for special tooling and production of multi-connector assemblies, are now available from Sealectro Corporation. These components are suited to limited runs and production of equipment requiring running changes.

The new Sealectro components are probes and jacks featuring floating contacts which allow for normal misalignment and rocking motions in connect/disconnect operations. The equipment manufacturer punches his chassis and rack to accept the " Press-Fit " probes and jacks. These may be placed in the most advantageous positions for associated circuitry, instead of a single connection point, as is necessary with the usual multi-point connector.

The Sealectro PR-400 probe and SKT-400 jack are the two components necessary to make up the complete rack and panel connection. Both provide a solder cup for termination of associated circuitry. Both are the usual " Press-Fit " design featuring a p.t.f.e. body with a through-chassis diameter of 0·148 in., requiring a 0·136 in. hole in the mounting panel. The combination of these components is good for many thousands of insertions with no appreciable increase in contact resistance. Preparation of the chassis and rack units may be done with any standard punch, or two-step drill, conforming to recommended dimensions. The units are available in all standard colour p.t.f.e. bodies for coding purposes.

Circle **40** *for further details.*

Industrial Contactor/Relay

B. & R. RELAYS LTD. contactor relay the Q 51 is for a.c. operation and operates both as a heavy duty switch and as a normal relay.

The Q 51, which complies with B.S. S775—1956 Clause 5—6 Class IV, has a patent pending and C.S.A. approval has been applied for. It is suitable for 440 volts 50 c/s 3 phase industrial supply with an inductive 10 amp rating.

There are two versions of the relay the Q 51/2 with two banks and the Q 51/3 with three banks. The coil can easily be changed for other voltages and the relay may be tropicalised to DEF5000. Operating speeds on the two bank are 10—30 ms for pull-in and 10—25 ms for drop out. Pull-in for the 3 bank is also 10—30 ms, drop out 15—25 ms. AMP Faston connectors can be supplied, though the terminals which are of the rising type captive clamp are designed to hold two 7/0—029 cables.

The Q 51 is designed to withstand a flash test of 2,000 volts, and a wide variety of normally open or normally closed or change over contacts are possible. The two bank version weighs 11 oz, the three bank 13 oz.

Applications for the Q 51 are wide, the relay has been under development for the last twelve months including prototype testing under actual working conditions. It may be used for example to control machine tool sequencies or for switching a 3 phase motor direct on line.

Circle **41** *for further details.*

Electronic Pilot Relay and Photo-electric Control

THE universal electronic relay Model KS. 18 from Britec Ltd. may be used either as a photo-electric control or as an electronic pilot relay. It replaces Models KS. 11, KS. 14, KS. 16 and LS. 61.

The KS. 18 is a high-sensitivity cold cathode switching amplifier and its output relay has two change-over contacts. It can be controlled by sensitive and high ohmic probes as an electronic pilot relay for partially conducting fluids or powders, or as a photo-electric control by a light-source and scanner unit with small photoconductor.

The KS. 18 is eminently suitable for use with mercury-contact thermometers, instrument pointers with single or minimum-maximum contacts for level control of fluids or powders, or with photocontacts for the supervision of measuring instruments, for edge control, strip control, and level or position supervision.

A supply voltage for 6 volt lamps is provided and it can be connected directly to the ELESTA light-source and scanner units with beams up to 20 feet (6 metres) long.

A special circuit incorporating various input and output sensitivities ensures clean and stable control even with gradual alteration of the control voltage. An observation lens, illuminated by the glow of the cold cathode tube, enables quick visual supervision.

Control KS. 18 is supplied either in a complete stove-enamelled metal housing with 4 terminal gland connections, or in a case with multi-plug terminal and a separate baseplate with multi-socket, for easy disconnection and reconnection if desired. This multi-connection terminal has a low contact resistance, and the case is secured to the baseplate by means of two screws.

Operating voltage:	220 V + 10%—15%, 50/60 c/s.
Consumption:	Control amplifier about 10 VA (with tube lit); or about 20 VA including photo-electric light source.
Lamp voltage supplies:	5·2 V; 5·6 V; 6·2 V; 6·8 V tapped; max. 10 VA.
Relay contacts:	220 V a.c., 6 amp ohmic load.
Counting rate:	4 to 5 max. per second (minimum response time = 100 milliseconds).

Circle **42** *for further details.*

Cobalt 60 Irradiation Units

Two irradiation units, of relatively low cost, for laboratory experiments with cobalt 60 radiation, have been produced by Atomic Energy of Canada Ltd. They are the Gammacell 100 and 200, and are available in the U.K. through Watson & Sons (Electro-Medical) Ltd.

The Gammacells 100 and 200 have a fixed ring of encapsulated cobalt 60 rods into which the specimen is moved. The ring of cobalt 60 rods is completely surrounded by a lead shield—no additional protection or special room is required.

The cell volume of the Gammacells 100 and 200 are $1\frac{1}{2}$ in. diameter × $4\frac{1}{2}$ in. high, and $3\frac{1}{2}$ in. diameter × $5\frac{1}{2}$ in. high respectively. Dose rates of up to 3×10^5 r/h in the centre of the irradiation chamber are available.

Operation is by electric motor and timer. The specimen is placed in the sample chamber which is lowered into the ring of cobalt 60 rods; at a pre-set time the sample is withdrawn. Access tubes are provided—one on the Model 100 and two on the Model 200—to take electrical connections, coolant, etc. Additional experiments can be carried out in a helical tube surrounding the source.

Dose rates outside the cell are less than 5 mr/h, 12 in. from the surface using the largest source.

Circle **43** *for further details.*

Head-on Type Multiplier Phototube

THE " venetian-blind " dynode type multiplier phototube, the RCA-8054, is a 3-inch diameter multiplier phototube specifically designed for scintillation counting.

Rating and performance characteristics of the 8054 are specifically measured with a light source having a spectral distribution closely matching that of typical scintillators.

Design features include a semi-transparent photocathode having a minimum useful diameter of 2·59 inches, a first dynode having a large area; a flat window to facilitate the mounting of flat phosphor crystals; and 10 dynode (secondary emitter) stages.

The 8054 has a median radiant sensitivity of $1{\cdot}5 \times 10^4$ amperes per watt at 4,400Å (approximately 20 amperes per lumen) when operated at a supply voltage of 1,500 volts.

The median equivalent anode dark current input of the 8054 is $5{\cdot}5 \times 10^{-13}$ watt at 4,400Å (approximately $4{\cdot}4 \times 10^{-10}$ lumen) at a sensitivity of 7,200 amperes per watt.

The S-II spectral response of the 8054 covers the range from about 3,000 to 6,500Å. Maximum response occurs in the blue region at approximately 4,400Å.

RCA-8054 is the commercial designation for the developmental type C-70030.

Circle **44** *for further details.*

Photo-electric Timer

THE Super Cub photo-electric timer being manufactured by Hird-Brown Ltd. can be used in industry wherever intervals of time have to be measured, for instance in method studies and in the timing of production cycles in automatic machines. A specific application in the motor industry could be on testing tracks.

The Super Cub is a transistorised unit which operates any two existing stop watches simultaneously by distant interruption of light beams falling on electric eyes or by making and breaking electrical contacts.

One of the principal improvements in the Super Cub is a special milliamp signal device to monitor photocells. The visible part of this device is a white signal fitted to the control panel which flashes when the photocells are operating correctly. The Super Cub is also adapted to make use of three Ever Ready PP7 batteries. Another improvement is the addition of a Traffolite panel to guard against stray magnetism which might affect the operation of the unit.

The control unit, which is completely self contained, measures $9 \times 6 \times 3$ in. and weighs 10 lb. All necessary operations are performed by a single three-position switch. Push terminals are provided for connection of external leads from the electrical eyes or contacts.

Circle **45** *for further details.*

Circle 355 for further information

UNICAM

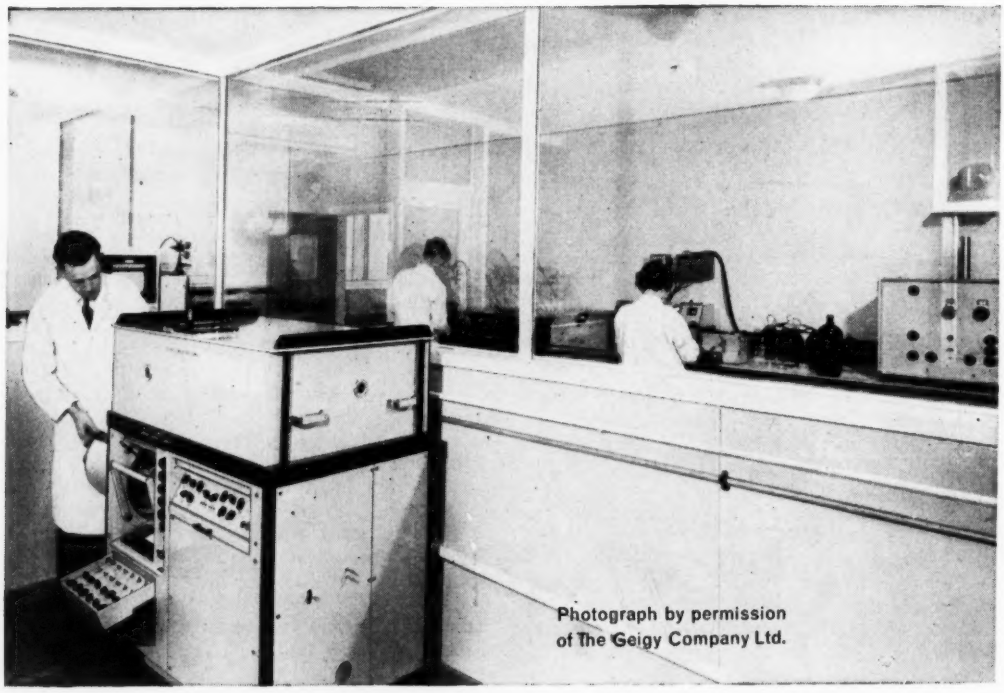
The highest levels of accuracy and reliability are essential to the quality control service of the pharmaceutical industry. The Unicam SP.100 Infrared Spectrophotometer provides more information in less time and with less effort—to performance levels previously associated only with research equipment built to specialist specification.

Detailed attention to operating systems and a comprehensive monitoring routine allow even the unskilled operator to achieve the outstanding performance offered by the SP.100.

For information on how the SP.100 can help in your laboratory please write to:

Unicam Instruments Limited,
York Street, Cambridge, England.

SP.100 Infrared Spectrophotometer



Other Unicam instruments appearing in this photograph are the SP.500 Ultraviolet Visible and Near Infrared Spectrophotometer and the SP.900 Flame Spectrophotometer.

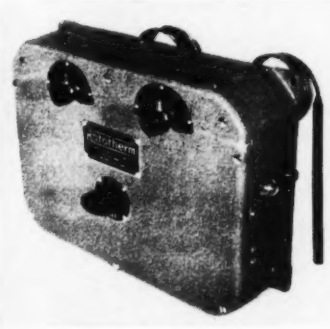
UNICAM INSTRUMENTS LTD · YORK STREET · CAMBRIDGE · ENGLAND

U2

Dual Zone Temperature Controller

A MERCURY-IN-STEEL, on-off temperature controller, Model No. 1039, which has independent circuits allowing control at any two points through one instrument, has been produced by the British Rototherm Co. Ltd.

Each of the two controller circuits consists of alloy steel Bourdon tubes, capillaries and temperature-sensitive bulbs, operating mercury switches rated up to 30 amp at 230/250 a.c. The differential is fixed but varies according to switching capacity.



Temperature controller Model 1039

Indicator lamps and bottom entry electrical conduit are standard. Temperature ranges are available between −20 and +1,000°F (minimum coverage 100°F) and the equivalent °C.

The case is aluminium alloy and the standard capillaries 10 ft copper sheathed with mild steel bulbs screwed ½ in. B.S.P.

Circle **46** *for further details.*

R.F. and Switching Transistors

THE GET88/89 range of r.f. and switching transistors, mounted in the JEDEC TO-5 can, is now available from the G.E.C. Semiconductor Division.

The GET88/89 range of germanium p-n-p alloy transistors is divided into three groups—for use in switching circuits, radio frequency amplifier and oscillator applications, and radio receivers.

Switching Transistors

	$V_{cb\,(max)}$ (V)	Typical h_{fe}	Min. f_α (Mc/s)
GET881	−15	45	3·5
GET882	−15	65	7·5
GET883	−15	90	15
GET891	−20	45	3·5
GET892	−20	65	7·5

R.F. Amplifier Transistors

	$V_{cb\,(max)}$ (V)	h_{fe} range	Min. f_α (Mc/s)
*GET880	−15	50 — 100	7·5
GET887	−15	50 — 100	3·5
GET888	−15	100 — 200	3·5
GET889	−15	50 — 100	7·5
GET890	−15	100 — 200	7·5

*Low noise transistor; maximum noise factor (1 kc/s): 5 dB.

Radio Receiver Transistors

GET883	1F amplifier
GET884	Mixer

All types are of similar construction, and have a common power dissipation rating of 100 mW at 25°C derating to zero at 85°C.

Circle **47** *for further details.*

Transistor Sound Level Indicator

DAWE INSTRUMENTS Type 1408D sound level indicator is an all transistor instrument complementary to the earlier Type 1408C which employed thermionic valves. The new version is considerably smaller, is more accurate and has a much longer battery life.

The instrument uses a high sensitivity Rochelle-salt crystal microphone which feeds into a special high input impedance circuit. This circuit is followed by a four position attenuator and buffer stage. The output from this section is applied to a two stage amplifier with associated resistance-capacitance weighting networks, designed to conform with the proposed I.E.C. specification for sound level meters.

The output of these networks feed into the meter amplifier circuit. This two stage system has the meter and rectifiers in a negative feedback line to provide good scale linearity.

Both amplifier sections have been designed to have very stable gains which are virtually unaffected by transistor parameter variations or supply voltage. This mode of construction employs a printed circuit with " end mounted " components resulting in a high component density and considerable saving in space. The instrument is housed in a moulded case fitted with the microphone and a moving coil meter of special ballistic properties. A transistor radio type battery is used which has a life of about 80 hours. A battery voltage check is incorporated.

Specification:

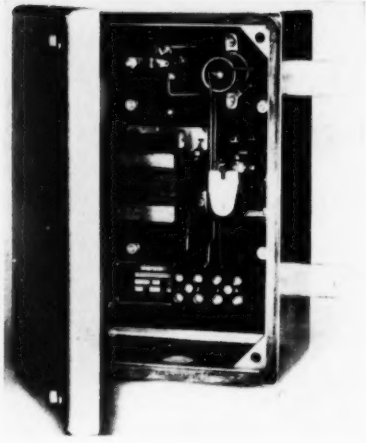
Sound level range:	64 dB to 110 dB above the standard sound pressure level of 0·0002 dyn/cm²
Frequency characteristic:	Three standard weighting curves A, B and C (I.E.C. specification). The C network is essentially flat from 32 c/s to 8 kc/s approx.
Microphone:	Minimum operating temperature 0°C (32°F). Maximum operating temperature 45°C (113°F). Maximum relative humidity 85%.
Attenuator:	70 dB to 100 dB in four steps of 10 dB.
Meter:	Calibration from −6 dB to +10 dB.
Calibration:	The overall acoustic calibration is set for the microphone supplied with the instrument against a reference microphone, the sensitivity of which is periodically checked by the National Physical Laboratory.
Power supply:	One 9 V dry battery Type PP4 Ever-ready or equivalent.
Dimensions:	6 × 3 × 2¼ in. (150 × 75 × 55 mm) overall.
Weight:	14 oz (450 gm) approx. with batteries.

Circle **48** *for further details.*

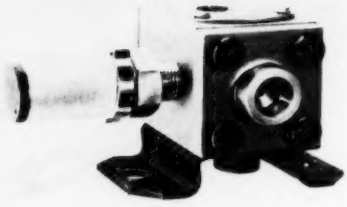
Feedthrough Pigtail Extension

A SOLDERING operation is completely eliminated through the use of the Sealectro Press-Fit Type FT-M-9 miniature feedthrough terminal with pigtail lead. The unit has a standard pin lug on the opposite end from the pigtail lead. This pigtail lead is 1½ in. long, but may be specified in other lengths upon special order. The lead allows bending to other terminations for point-to-point wiring. It is especially adaptable to printed wiring boards and is popular in computer assemblies.

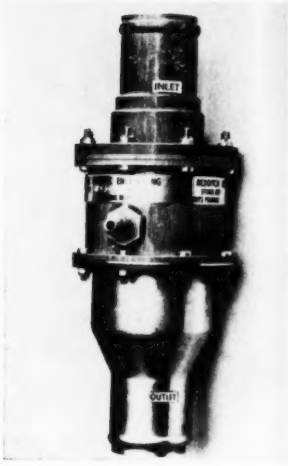
Circle **49** *for further details.*



A.C. load detector KR/CH



Silencer attached to pneumatic control valve



Dual inward/outward vent valve

A.C. Load Detectors

LONDEX saturated choke a.c. load detectors are for use in a.c. circuits which are subject to very large current fluctuations, i.e., they will detect loads of fractions of an amp and will withstand the continuous passage of current of the order of 25 to 50 amp.

A typical application is in connection with diesel generator sets where the detector unit is connected in series with the output of the generator and will shut down this set when all loads are switched off. Under these conditions, it is necessary for the unit to operate safely on, say, a 60-watt load and yet be capable of withstanding the maximum output, which may be 25 to 50 amp, of the generator.

The load detector equipment consists of a saturable choke working in conjunction with a sensitive relay which is operated by the voltage drop across the choke. In addition to the above, each unit contains a rectifier and condenser and the whole is mounted on an insulated base and fitted in an industrial sheet steel dustproof casing with hinged lid and suitable for conduit entry.

The load is connected in series with a choke. A relatively small a.c. current will provide a voltage sufficiently large to operate the relay and will not increase materially when the load current rises.

The voltage drop across the load detector at the maximum current values is approximately 7 volts.

Standard units are for use on single-phase supplies. Units for use on 3-phase can be manufactured to order.

Four types are available as follows:

25-*Amp Type*

KR/CH requiring a minimum of 0·3 amp. SSR/CH requiring a minimum of 0·2 amp. The choke is rated continuously at 25 amp or intermittently at 30 amp.

50-*Amp Type*

KR/CH requiring a minimum current of 0·5 amp. SSR/CH requiring a minimum current of 0·3 amp. The choke is rated continuously at 50 amp or intermittently at 60 amp.

Contacts on the relay can be normally open, normally closed or changeover, and a typical rating is 3 amp at 250 V a.c.

Prices range from £9 10s. 6d. and delivery of small quantities can be made in three weeks.

Circle **50** *for further details.*

Silencers for Pneumatic Control Valves

POROUS PLASTICS LTD. have developed a range of silencers suitable for the complete range of pneumatic control valves manufactured by Martonair Ltd. In addition, the silencers can be fitted to any other make of valve.

The silencers are made from Vyon, a porous plastic produced from high density polyethylene of the Ziegler type.

The silencers fit directly into the exhaust ports of the valves and the exhausting air escapes to atmosphere through the porous plastic body. This special construction is extremely compact and efficient and the porous nature of Vyon prevents clogging and freezing up.

Circle **51** *for further details.*

Vent Valve

A NEW dual inward/outward vent valve, the R.V.63, for use in the pressure control of tanks in fuel systems, has been developed by The Hymatic Engineering Co. Ltd.

The inward venting is controlled by a lightly spring-loaded diaphragm. This normally operates during a dive with the object of maintaining as closely as possible a positive pressure during flight. Coaxially the outward relief valve is spring-loaded and either operates during climbing or relieves excess pressure caused by temperature variations when the aircraft has been standing on the ground.

For refuelling on the ground it is necessary to have the vent held fully open in order to cope with the high outward flow of air as it is displaced by the incoming fuel and to present the minimum restriction should a burst of fuel emerge inadvertently through the air vent as a result of delayed operation by the refuelling shut-off system. For this function the outward relief vent is held in the fully open position by a piston which overrides the spring-loading. The piston is operated by

pressure in the refuelling lines and "jacks" open the outward valve.

During inward venting the valve passes 20 ft³/min with a pressure drop of 0·3 lb/in² at ground level conditions. The outward relief vent has a nominal flow-off pressure of 3 lb/in² and a 6 ft³/min air flow at 3·4 lb/in² back pressure. With the outward relief vent held open during refuelling, it will pass 35 gallons with a minimum fuel servo pressure of 26 lb/in², thus allowing for a pressure drop between the refuelling bowser, the aircraft fuelling connection and the R.V.63 fuel servo connection.

The R.V.63, now in production, is fully compatible with fuel. It is compact, weighs 1¼ lb and is fitted with 1½ in. beaded connections.

Circle **52** *for further details.*

Form Error-measuring Instrument

THE Elliott "Rondell", is a form error-measuring instrument which measures not only the roundness errors of an object but also errors in concentricity, in perpendicularity, in parallelism and in axial alignment, to within 3 micro-inches.

The instrument consists basically of an ultra-precision bearing of novel design which has the property of self-improvement so that its accuracy increases with use. This bearing defines a reference axis and a reference plane for the measurement of the object under test, and enables the exact relationships between its various surfaces to be determined. Surfaces are examined by means of an electrical pick-off probe, and errors are displayed on a meter or are recorded on a polar chart.

The Elliott "Rondell" is a robust instrument intended for workshop use, under reasonably clean conditions, as well as for laboratory applications.

Circle **53** *for further details.*

"Varicoil" Magnetometer

GRIFFIN & GEORGE have produced a new instrument for use in the advanced phase of the new Physics for Grammar Schools Syllabus of the S.M.A. and A.W.S.T. Pilot Scheme, and for the advanced level in Physics in the G.C.E.

This instrument, the Griffin "Varicoil" magnetometer, an improved version of tangent galvanometer, enables the relationship between field and all three variables in the reduction factor to be established, where the conventional galvanometer allows only the F : i relationship.

The "Varicoil" magnetometer can also be used to demonstrate that, for a given current, the field at the centre of a circular field is inversely proportional to its radius; or that, for a given current, the field at the centre of a circular coil is directly proportional to the number of turns.

The Griffin "Varicoil' magnetometer consists of a 12 × 12 in. board carrying five concentric circular turns of different radii in the form of a printed circuit with a deflection magnetometer placed at their centre. A tapped, wire-wound circular coil concentric with the others and in the same plane has one side exposed for easy measurement of its mean diameter. It has a total of 15 turns and is tapped at 1, 3 and 7 turns, so that by a selection of the terminals it is possible to obtain a wide range of turn values. The 7 in. diameter plastic base carries a series of terminal sockets labelled to correspond with the single turns and the tapped coil respectively. The leads consist of twin flex (to minimise magnetic disturbance) terminating in wander plugs which give simple and quick alterations to connections and eliminate the necessity for a reversing switch. The magnetometer rests on a slightly tapered tubular support to allow a degree of levelling.

The magnetometer is priced at £15 12s. 6d.

Circle **54** *for further details.*

Instrument Warning Device

THE Stanley Sealey instrument warning device has been developed as an "add on" unit for use with standard instruments where it is required to initiate some action in the case of predetermined limits of operation being exceeded.

The device consists of one or more photo-electric heads and a control unit, and in the event of one or more or a certain combination of several limits being exceeded the device closes a pair of contacts in the control unit. The device is fail safe and the contacts may be used to initiate any action required.

The head is approximately ¼ × ¼ × ⅜ in. and when used with a standard meter is merely applied to the glass front of the meter at the predetermined level and below the meter scale. The head is small enough not to obscure the scale in the smallest meter and can be moved from meter to meter as the need arises.

The head may also be used with pen recorders, thermometers, etc., as well as with standard meters. A recent application is the monitoring of a group of oil pump tubes to detect the passage of globules of oil and to shut down the plant if the period between globules is excessive.

Circle **55** *for further details.*

Elapsed Time Meter

AN elapsed time meter for recording the time a piece of equipment has been in use is being produced by English Electric. It can be applied to any equipment used intermittently and on which planned maintenance or a time log is required, e.g., pumps, ventilating and heating systems, valuable vacuum valves (X-ray transmitting tubes, etc.).

The meter is normally connected so that it is automatically switched on and off with the apparatus being metered. It can register up to 9999·9 hours in steps of 0·1 hour.

The cyclometer register is driven by a self-starting, non-reversing, synchronous motor, through a train of gears. Operation is on a.c. supply in the voltage ranges 100-125, 200-250, and 400-440. The frequency can be 50 or 60 cycles.

The meter is available in two case types.

The first, Type H21M, is a 4 in. square, flush mounting, switchboard pattern case. The motor is mounted internally and two terminals are provided on the baseplate to connect the motor to the supply. The meter has a small revolving pointer to indicate that the motor is energised.

The second is a 2½ in. or 3½ in. Type S25 or S35, square moulded black plastic case designed primarily for panel mounting. The motor is mounted externally and

connection to the supply is made via a pair of flexible leads. It is lubricated with a special grease for operation in extreme temperatures.

Circle **56** *for further details.*

Transistorised D.C. Timer Unit

CURRENTLY being used in breweries for automatic keg racking, B. &. R. Relays' new transistorised d.c. timer unit has many applications in control and automation processes.

It is an electronic interval timer for opening and closing relays at predetermined time intervals and is capable of operating between 12 and 50 volts d.c. with a maximum time delay of three minutes. This new B. & R. timer has a repeat accuracy of ±10%. Ambient operating temperatures are between −15 up to +60°C maximum. It is fitted with single pole change-over contacts.

The timer unit can be operated from a low voltage d.c. source. It weighs 1 lb 12 oz and is 4½ in. square by 2⅛ in. high, excluding the time adjustment control knob.

Circle **57** *for further details.*

A.C. Automatic Voltage Stabiliser

THE Type TS-1 a.c. voltage stabiliser provides distortionless stabilisation over an input voltage range of 25%, with an output of approximately 1 kVA. Alternative connection gives approximately 2 kVA output with 12½% input range.

The response speed is 40 volts per second, and the accuracy is better than ±0·5%, from zero to full load.

The stabiliser comprises a motor-driven Variac variable transformer, controlling the primary of an auxiliary transformer, the secondary of which is connected in series with the supply, so as to inject a variable aiding or opposing voltage to correct for any error. The motorised Variac is automatically positioned by a transistorised sensor unit, to maintain the output voltage at the required value. The output voltage setting may be any value between 200 and 254 volts.

The plug-in sensor unit is a transistorised servo-amplifier which continuously monitors the stabilised output voltage, a rectified sample of which is compared with a Zener diode reference. The error voltage is amplified and applied to a pair of transistors controlling the armature supply to the d.c. servo-motor, the field of which is continuously excited.

The Type TS-1 stabiliser is provided with a dual-range transformer having two secondaries, which can be connected in series or in parallel. With parallel connection, a very high power rating for the size of equipment is obtained, with range sufficient to compensate for supply voltage variations within the statutory limits of ±6%. With series connection, the same unit provides a very wide correction range, covering all likely mains variations even under abnormal conditions.

With each connection three different input voltage ranges can be selected, by means of tappings provided on the Variac. For series connection these ranges are −17½% to +7½%, ±12½%, and −7½% to +17½%. The correction range in parallel connection is half that for series connection.

Circle **58** *for further details.*

L.F. Signal Generator

THE Airmec l.f. signal generator Type 252 is designed for the generation of pure and highly stable sinewave signals in the frequency range 30 c/s to 300 kc/s.

The oscillator consists of a Wien bridge network with thermistor feedback amplitude control, followed by a negative feedback push-pull amplifier; tuning is by means of a variable capacitor and covers the frequency band in four decade ranges with a calibration accuracy of ±1% ±1 c/s. Long term frequency stability is better than 0·1% ±1 c/s over the frequency range, and stability with supply voltage variation is 0·02% (approximately) at 1 kc/s for a variation of 10%.

A screened and balanced output transformer provides either balanced or unbalanced outputs at an impedance of 600 ohms; circuit design is such that the output impedance remains constant regardless of frequency and attenuator setting, and the output is monitored by a crystal diode voltmeter. The output can readily be made fully floating by removing an external link on the front panel, and in this condition will withstand 300 V d.c. or peak a.c. to earth.

An output control provides smooth variation of output over the meter range. In conjunction with a step attenuator, it enables the output level to be set to any value from less than 1 mV to 15 V open circuit with an accuracy of ±0·2 dB per step, ±0·3 dB overall. Output level variation over the whole frequency range of the instrument is approximately ±0·5 dB, rising to ±1 dB on the 0 dB attenuator setting with 600 ohm resistive load.

Circle **59** *for further details.*

Small Panel Instruments

CROMPTON PARKINSON LTD. are manufacturing a range of miniature instruments suitable for use on grouped control boards, multi-motor starter panels, mimic diagram boards, etc., where the general trend in design towards smaller dimensions renders the traditional switchboard instrument too large.

The instruments have circular scales, in which the pointer travels through an arc of 240°, and have scale lengths approximately twice those of the corresponding conventional 90°—100° short scale instrument.

Supplied with moving-coil or moving-iron movements, these voltmeters and ammeters have square or round bezels. Square bezel instruments have 2 inch dials with scales 3⅛ inches long; round bezel instruments have 2½ inch dials with scales 4¼ inches long. The diecast cases are nitrogen filled and sealed and their dimensions conform with Ministry of Defence Specification No. DEF-62. Alternatively, the instruments can be supplied in unsealed metal or plastic cases.

Based on the designs of the larger Crompton Parkinson industrial type circular scale instruments for switchboard use, these small panel instruments are robust in construction.

These scaled instruments are the first of their size and type to pass the Admiralty shock test as applied to instruments, and have been approved for use in fighting ships. During the course of the Admiralty shock tests, they successfully withstood shocks many times greater than any likely to be experienced under normal industrial conditions.

Circle **60** *for further details.*

ETHER LIMITED

Circle 356 for further information

'TRANSITROL'

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from £35.10s
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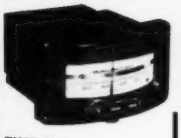


TYPE 990:
Two-position on/off.

Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric heaters.

Applications:
Salt-baths for heat-treatment of metals.
Vitreous-enamelling furnaces.
Muffle furnaces.
Hot-air ovens.
Drying kilns.
Crucible furnaces.
High-temperature alarms.
Extruding and moulding machines, etc., etc.

TYPE 991:
Anticipatory

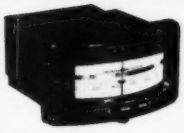
Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric Heaters.

Applications:
Extruding machines and moulding presses for plastics, rubber, etc.

Die-casting machines.

Furnaces for crystal growing.

Chemical processing.
Food packaging machinery, etc., etc.



TYPE 992:
Proportioning (stepless)

Operating:
Saturable reactors.

Applications:
Electrically-heated equipment requiring extremely accurate temperatures, e.g. plastic extruders for high-quality production.

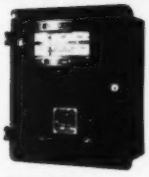
Electric furnaces employed on research.

Electronic production, etc., etc.

TYPE 993:
Three-position (employing any combination of the preceding control systems).

Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric heaters.
Saturable reactors.

Applications:
For the independent control of sequential heating and cooling or for controlling a floating valve in:—
Salt-baths for heat-treatment of metals.
Vitreous-enamelling furnaces.
Muffle furnaces.
Crucible furnaces.
Extruding machines.
Moulding presses.
Die-casting machines, etc., etc.



TYPE 995:
Continuously-acting Proportional (with manual reset)

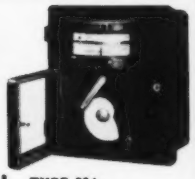
Operating:
Motorised proportioning valves.

Applications:
Gas-fired or oil-fired molten-metal vats.

Continuously-fed furnaces.

Lehrs.

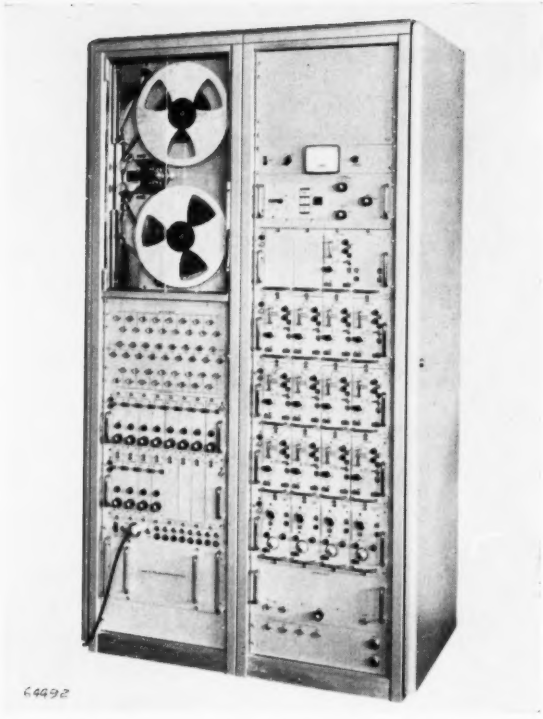
Drying ovens and kilns, etc., etc.



TYPE 994:
Time-Temperature (employing any one of the preceding control systems).

Operating:
Solenoid valves.
Motorised valves.
Motorised proportioning valves.
Contactors. Relays.
Electric heaters.
Saturable reactors.

Applications:
For controlling the rise and fall of temperature over a given period of time in:—
Pottery kilns.
Food processing.
Heat-treatment of metals, glass, plastics.
Research, etc., etc.



Six-speed instrumentation tape recorder Type MR210

Tape Recorder

EPSYLON INDUSTRIES LTD.'s new six-speed instrumentation tape recorder, Type MR210, provides six tape speeds between $1\frac{7}{8}$ and 60 in/s (4·75—150 cm/s) and has a capacity of 4,800 feet (1500 m) of standard base tape.

Up to sixteen recording channels using either in-line SBAC or interleaved IRIG heads can be supplied.

Wow and flutter are low and if required flutter-compensation can be provided. A closed-loop tape path is used.

The tape deck may be mounted either horizontally or vertically and its dimensions are:

Height:	$31\frac{1}{2}$ in.	(80 cm)
Width:	19 in.	(48 cm)
Depth:	12 in.	(30·5 cm)

Circle **61** *for further details.*

Function Generator

THE v.l.f. function generator, SG.88, produced by Advance Components Ltd., is basically an optical/mechanical system. In this generator the conventional oscillator circuit is replaced by interchangeable transparent rotating discs, scanned by a narrow light beam. Printed on each disc is an opaque pattern representing in polar co-ordinates the wave-shape or function to be produced. The range of wave-shape is virtually limitless, requiring only that the function from which each is derived is single-valued and repetitive. The direction of rotation of the disc can be changed to reverse the time sequence of the output waveform.

The output frequency is continuously variable from 0·005 c/s up to a nominal maximum of 50 c/s. By increasing the number of complete patterns on the disc, the upper frequency limit can be increased to several times the nominal value.

Acceleration of the disc on the two lower frequency ranges permits an almost instantaneous start from any pre-determined point of the waveform. The periphery of the disc is calibrated in degrees for this purpose.

Sweep facilities are provided on the two upper frequency ranges to give rapid assessment of the response of the equipment under test. The frequency sweep commences at any pre-set frequency and proceeds logarithmically to the upper frequency limit of the range.

Specification

Frequency range:	0·005 to 50 c/s for a single cycle disc, or dependent on number of cycles per revolution. (Lower frequencies possible, but with decreased accuracy.) Dial calibrated linearly 0 to 5 and 0 to 10 with four-position decade multiplier × 10, × 1, × 0·1, × 0·01.
Frequency calibration accuracy:	±1% of full scale.
Output voltage:	200 μV to 20 V, peak-to-peak, high impedance. Selected by a five-position decade multiplier and a continuously variable attenuator.
Output amplitude variation:	Within 1 dB over entire frequency range.
Rectangular waveform rise time:	Varies from 300 ms at 0·005 c/s to 0·3 ms at 50 c/s. When internal triggered device is switched in the rise times are less than 5 μs on all frequencies.
Output waveforms:	Any single-valued repetitive function. Angular resolution of optical system 0·5°, frequency response of whole system 0 to 3 kc/s.
Output impedance:	At maximum output, 300 to 3,000 ohms depending on frequency.
Power supply:	105—126 V, 190—252 V, 50—60 c/s. Consumption approximately 165 watts.
Dimensions:	$19\frac{3}{4}$ × 13 × 15 in. (50 × 33 × 38 cm).
Weight:	80 lb (36 kg).

Circle **62** *for further details.*

Dust Measuring Equipment

THE AEI dust measuring system responds to dust area but overcomes the disadvantage of optical methods whereby flue gas velocity affects the indication, by automatically taking into account the product of particle number, velocity and area. This is achieved by providing the continuously flowing sample of gas with a corona environment, where all solid particles become electrically charged; the charge is proportional to the particle surface area. The charge on the particles collected thereby forms a current potential proportional to particle number, area, and flow velocity. After amplification, this current is used either to indicate or to record the level of pollution. A warning can be given should the pollution rate rise above some predetermined level.

When installed in a duct of a chimney, the inlet of this sampling equipment is placed so that average velocity conditions are presented to it. The outlet, in

the form of a conical diffuser to overcome the impedance of the equipment to the flow of the gas being sampled, is also placed in the main duct stream.

To prevent condensation of moisture in the sampling equipment, the temperature of working parts is kept above dew point. Build-up of dust in the equipment is prevented by automatically purging with air for a few seconds once every twenty minutes.

The equipment, being highly sensitive, will respond to particle diameters ranging down to 0·01 microns, and can monitor flue gases leaving dust-arresting plant of large boilers with burdens of about 0·04 grains per cubic foot rising to 2 grains per cubic foot during soot blowing.

A recorder chart is available, showing 24 hours' running on a continuous load station.

Circle **63** *for further details.*

Varnish Coatings

VARNISH coatings of molybdenum disulphide are widely used for lifetime dry lubrication of lightly loaded components such as ball and roller bearings, and for bearing surfaces in general gear teeth, slides, tool faces, dies and moulds where the conditions do not permit the use of more conventional forms of lubricant.

A systematic study has recently been made in the Rocol Laboratories to determine the relative values of various formulations in view of a tendency in U.S.A. to base these products on thermo-setting resins which give very hard resin bonded films, but require special attention and care to produce satisfactory results. The investigations have covered the nature of the resin bonding material (and its solvent), the proportion of molybdenum disulphide to resin, and the proportions of total solids.

The result of these studies confirmed that the company's Molytox Plus was the best material for general application with the greatest ease. In addition Rocol are now offering Molydite Plus as a subsidiary grade for special work where the special attention and high temperature baking necessary for its proper application can be carried out. The two varnishes contain the same proportion of molybdenum disulphide and of resin, but differ in the natures of the resins and, therefore, of the solvents.

The following method of application is recommended. Brushing, spraying or dipping methods can be employed for the actual application:

1. Degrease work
2. Dry at 100°C (212°F)
3. Apply Molydite Plus to work, taking care to keep the fluid agitated
4. Dry at 200°C (392°F) for 60 minutes in oven
5. Remove from oven and cool
6. Burnish with soft cloth or leather
7. Examine film for holes or discontinuities, and re-treat if necessary.

It is necessary to carry out the full treatment, and the oven temperature and period of baking are essential to obtain a firm film.

Molydite Plus should be used for the most severe service and for all conditions where the surface has to resist contact with hot oils, solvents, acids, alkalies and other reactive chemicals.

The price for a 40 lb drum is 26/- per lb; for 8 lb tins, 26/3d. per lb; and for 2 lb tins, 27/- per lb.

Circle **64** *for further details.*

Air-powered Filling Machine for Inflammable Liquids

THE FILAMATIC automatic filling machine introduced by Shandon Scientific Co. some months ago is now available in an air-powered version specially designed for the handling of inflammable liquids.

The new model, the DAA-5, is equipped with dual nozzles and has a volume range from a few drops to eight ounces per stroke per nozzle—a maximum of sixteen ounces per stroke. A dual sixteen-ounce model is also available to special order. Filling rate is adjustable from 5 to 40 fills per minute.

The DAA-5 is powered by a geared-head rotary air motor operating at 40 lb/in² pressure, the motor being coupled to two reciprocating piston pumps. The volume dispensed by each pump can be varied by means of a graduated micrometer mechanism calibrated in 0·001 in. stages. Interchangeable pump units adapt the FILAMATIC DAA-5 for handling free-flowing, semi-viscous or viscous liquids. All parts in contact with liquid are of stainless steel or Teflon. Interchangeable glass and plastic pump assemblies are available for use with metal-sensitive liquids.

Circle **65** *for further details.*

Combined Electronic Relay/Timer

THIS unit combines the two functions of level control and timer on one chassis. It has been designed by Elcontrol Ltd.

The unit is constructed on a modified form of the LR9 printed circuit board and will normally be supplied in Type 25B case consisting of a cast aluminium base with a deep drawn sheet steel cover, the base is fitted with ¾ in. conduit entry holes. The unit can be supplied chassis only to special order. Mains supply, initiating circuits, and external relay connection are by means of a wrap round 14-way connector block.

The timing ranges available are 1·5 to 15 sec or 5 to 100 sec. The repetitive accuracy is ±5% on time. The reset time is 3 to 5 sec.

The price for the chassis only version is £13 10s. 0d., in the 25B industrial case the price is £17 10s. 0d.

Circle **66** *for further details.*

Power Cylinders

AIR AUTOMATION have introduced a new range of square ended air cylinders of tie-bar construction. The first sizes to be available are those of ¾ in. and 1 in. bore in single acting, double acting, and single acting spring return patterns.

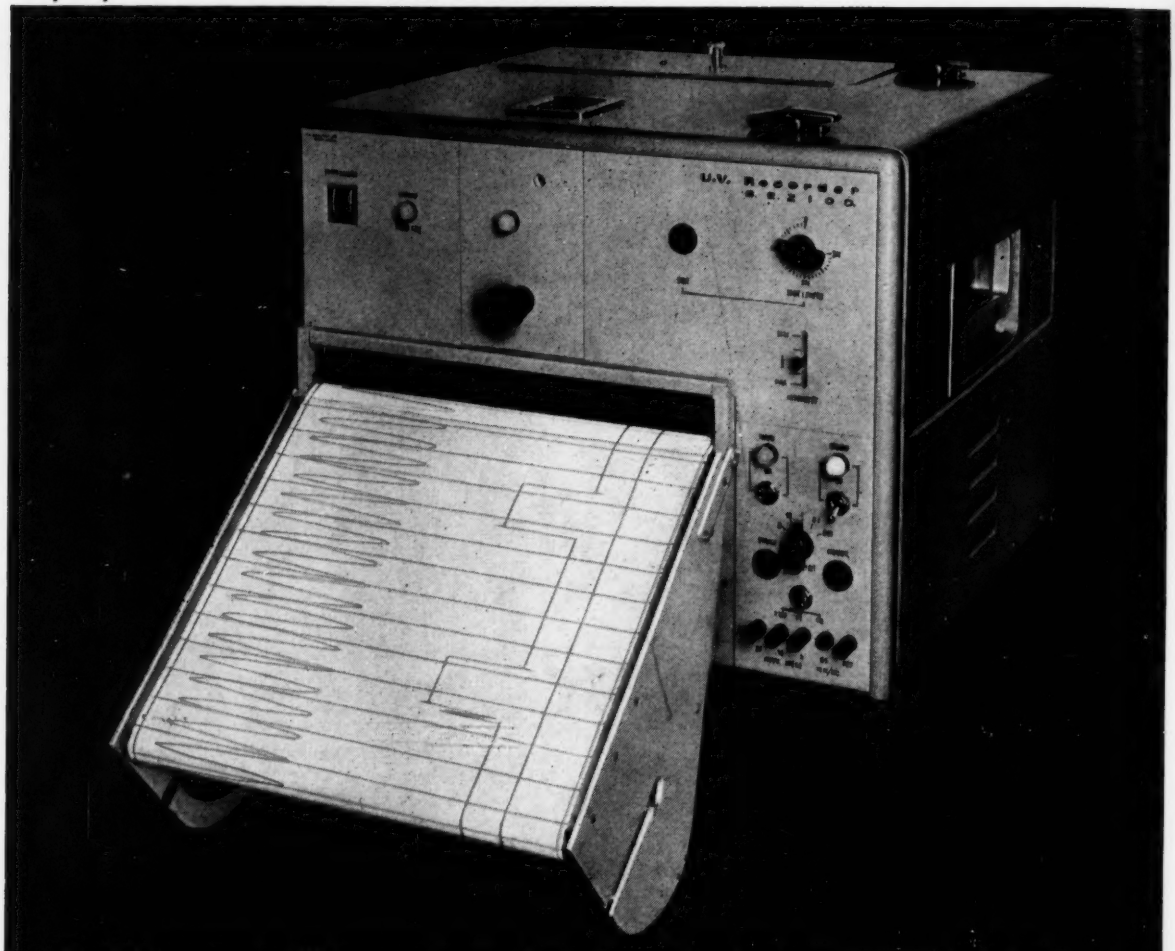
These cylinders have stainless steel rods, brass bodies, and neoprene distributor type "U" seals for both rod and piston.

All cylinders are provided with screwed nose, front face mounting, and rear trunnion mounting, as well as screwed base mounting, and in addition front flange mounting plates or foot mounting plates can also be supplied if required.

Circle **67** *for further details.*

Circle **357** for further information

S|E|L 12" UV Recorder



The S.E. Laboratories UV Recorder deflects a high-intensity UV light beam by means of sensitive mirror galvanometers across a moving strip of immediate-print-out photographic paper, requiring no processing. The Recorder thus gives a fast, clear and accurate record, together with an unsurpassed range of advanced features: ● *Direct writing with fast presentation* ● *High sensitivity—2.0 μA/cm at 100 c/s* ● *High frequency response—up to 5 kc/s* ● *Up to 50 recording channels* ● *Paper speed range from 1.25 to 2,000 mm/sec, push button operation* ● *Trace intensity control; Trace identification* ● *Remote control facility* ● *Shot control—exposes pre-determined length of paper* ● *Two Models: SE 2000, up to 25 galvanometers, 6" wide paper; SE 2100, up to 50 galvanometers, 12" wide paper*

S|E|L

SEL offers a complete, integrated system of Data Handling instrumentation. For details of the UV Recorder, and of all other SEL products—transducers for pressure, acceleration and displacement, control and venting valves, frequency DC converters, flowmeters, demodulators, carrier amplifiers, data loggers and complete systems, please contact:

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NEWS OF THE INDUSTRY

INSTRUMENTS

RADIOVISOR PARENT LTD. have been granted a non-exclusive licence by the Central Electricity Generating Board to manufacture and sell the **"Everclean" window** which has been developed by the Central Electricity Research Laboratories and for which Patent Application No. 5654/59 has been lodged by the Board.

The company claim to have designed the first industrial smoke density indicator over 30 years ago and to have originated air purging of the windows to keep them free from soot deposits. In many instances this is satisfactory, but the "Everclean" window relies on the inability of dust and soot particles to travel along a bank of tubes or a honeycomb in which each tube or cell is long compared with its diameter. Tests carried out by the Board have shown that window cleaning can be reduced to once in 12/18 months.

A design of "Everclean" window is also available for use where a positive flue pressure exists. In the past it has been necessary, in these conditions, to employ compressed air for purging.

A **molecularised computer** one-tenth the size and weight of a transistorised computer with the same capabilities is now under development at the Westinghouse Electric Corporation's air arm division.

Unlike miniaturised circuitry which achieves size and weight reductions through the use of smaller components, molecular electronics makes unnecessary the familiar tubes, transistors, and resistors of the type found in a television set.

In place of these components a solid semiconductor crystal performs the same functions through the rearrangement of its internal structure to form a functional electronic block. Electronic behaviour occurring within or between regions of the block gives the same effect as an electronic circuit. In the molecular computer such blocks will perform intricate electronic operations such as switching, amplification or other logic functions.

This computer will weigh less than 15 pounds and occupy less than one-third of a cubic foot instead of the 175 pounds and three cubic feet required by a similar conventional transistorised computer.

Molecular electronic design of systems including the computers reduces the number of connections and components. Therefore, there are fewer points of possible failure. In one instance 26 molecular blocks do the work of 118 conventional parts and a study is well along to reduce the number of molecular blocks to six and later to possibly three.

Another of the anticipated benefits of molecular electronics is an eventual reduction in cost of equipment and its operation.

An **electronically-controlled contour grinding machine,** which works to a high degree of accuracy, has been installed at the Royal Aircraft Establishment, Farnborough, for producing templates used in the manufacture of aerofoil sections for aircraft models.

These models, which are employed in high-speed flight simulation tests in wind tunnels, are scaled-down copies of proposed aircraft which are still on the drawing board, so the models must be made to very fine accuracies in order to retain the same proportional accuracy as the aircraft. This ensures that the models will behave in the same way in the wind tunnel as the aircraft would under flight conditions.

The grinding machine is tape-controlled by the EMICON system and the complete equipment is supplied by EMI Electronics Ltd. The grinder is made by High Precision Equipment Ltd., and the system is designed for an accuracy of ±0·0005 in. on a template which may be up to 30 in. long.

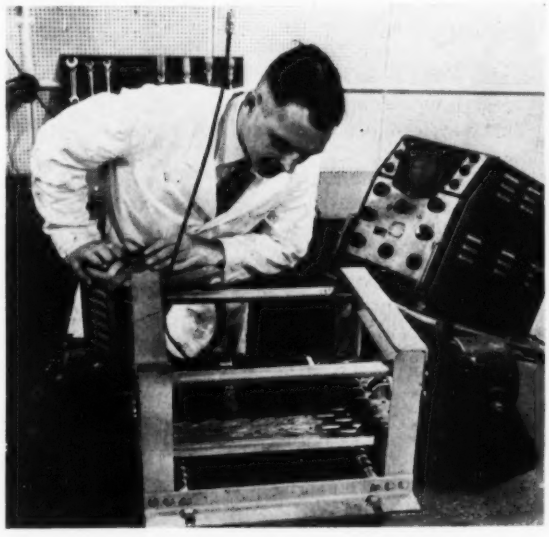
BECAUSE of additional new equipment and larger tooling capacity for their **polythene cable strapping stud** production, Hellermann Ltd. are making certain price reductions.

1. *Polythene Cable Studs* (small) have been reduced by approximately 15% to 1/10d. per 100. (Previously 2/2d. per 100.)
2. *Polythene Cable Studs* (large) have been reduced by approximately 25% to 1/11d. per 100. (Previously 2/7½d. per 100.)
3. *High Density Polythene Cable Studs* (small) have been reduced by approximately 15% to 2/3d. per 100. (Previously 2/8½d. per 100.)
4. *High Density Polythene Cable Studs* (large) have been reduced by approximately 25% to 2/4d. per 100. (Previously 3/2d. per 100.)

Hellermann Ltd. also announce that Helvin Cable Strapping (Part Nos. HV.3254 (5/16 in.) and HV.3341 (½ in.)), which has previously been supplied in black and transparent only, is now available in five additional colours: yellow, red, green, blue and white.

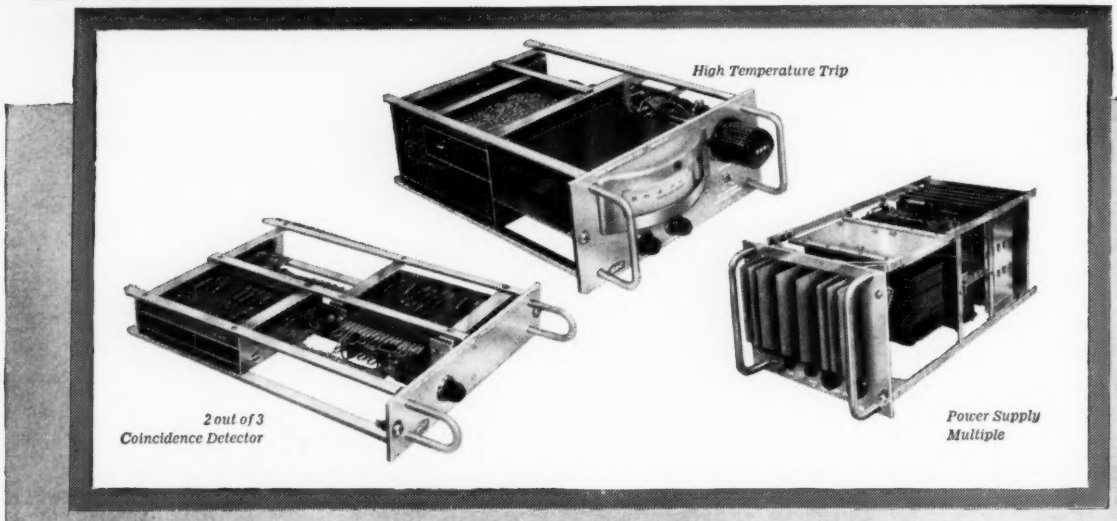
NEW **closed-circuit colour TV** from Britain designed for hospital use was among the highlights of the Fourth International Conference on Medical Electronics which opened in New York on the 17th July.

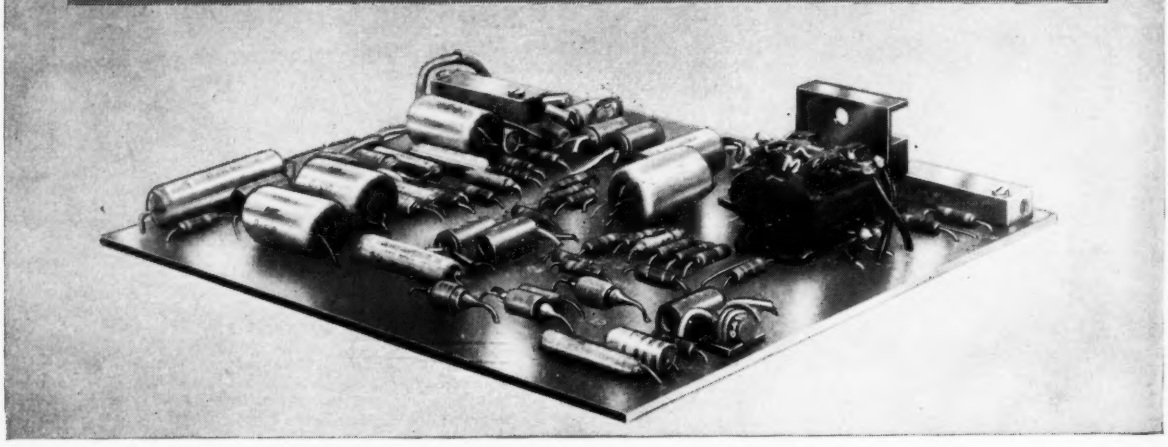
The colour system, designed by E.M.I. Electronics Ltd., was demonstrated for



Cossor Instruments oscillograph Model 1049 being used in vibration testing on Ultra aircraft intercomm control equipment at the Greenford factory of Ultra Electronics Ltd. (Reproduced by courtesy of Ultra Electronics Ltd.)

Circle 358 for further information





Gains of up to 200,000 over a range of output voltage of ± 5 volts are readily obtainable with the GEC transistorised DC amplifier.

It is a high-gain directly-coupled amplifier providing over accurate amplification of inputs as low as 50 microvolts over a temperature range of +10°C to +45°C. A low value of drift of zero setting accommodates supply line changes and changes of ambient temperature.

Used as the main sub-unit in a number of equipments, this amplifier is suitable for a variety of applications, some of which are illustrated here.

These, in turn, are but a few of an extensive range of electronic equipments developed and manufactured by the Electronics Division of GEC.

TRANSISTORISED DC AMPLIFIER by G.E.C.

For further information please write to:

THE GENERAL ELECTRIC CO LTD OF ENGLAND

Electronics Division, Lower Ford Street, Coventry, England

Smee's 62

the first time to leading American surgeons by Fairbanks Morse & Co., major industrial subsidiary of Fairbanks Whitney Corporation, under a recent marketing agreement with the British company.

The large-screen projector used showed medical men how operations can be screened to big audiences giving true-to-life colour reproduction.

The new E.M.I. colour camera is stated by the company to be more compact, less expensive and able to work under poorer lighting conditions than any available in the U.S. Experts here believe that it will help to speed medical training programmes to relieve the growing shortage of skilled doctors.

FISCHER & PORTER LTD. have improved the ruggedness and reliability of their range of "snap in" glass tube **Flowrators.**

The company are now making their glass metering tubes with flame polished ends, thus effecting an improvement which greatly reduces the possibility of accidentally chipping the tube in the course of removing it from or replacing it in its carriers.

Flame polishing makes the tube ends round and smooth in section and gives them additional strength. Flame polishing is now a standard operation in the manufacture of Fischer & Porter glass metering tubes of all sizes for the whole range of Flowrators.

Skybolt air-to-surface missiles are to be carried in the Avro Vulcan B.2 bomber and A.E.I. Electronic Apparatus Division are specifying the modifications necessary in the Vulcan's existing navigation system to suit Skybolt. A.E.I. are also developing and manufacturing transistorised conversion equipment for linking the existing system with that of the new missile.

ULTRA ELECTRONICS LTD. have received an order from Karenza Products Ltd. for Dialalarm **remote warning systems.** This equipment is to be incorporated into the company's security system.

The Dialalarm provides for automatic warning of any variation in certain standard conditions. One of its principal uses is as a burglar or fire alarm, but it can also be used to alert attention to mechanical or electrical failures.

CERTAIN of **B. & R.'s Type C.03 relays** have been approved by the Admiralty for use on 220 V and 440 V 15 amp supplies. These relays have satisfactorily passed the shock requirements laid down for Class "A" equipment.

EPSYLON INDUSTRIES LTD. have received from Messrs. Rolls-Royce an order for four **flight recorders** and from Messrs. Tweedale & Smalley an order for a number of automatic controllers for textile machinery.

THE PLESSEY Type 4 **precision temperature controller** has now been brought to the stage of development where it is accurate to within $\pm 1°C$ over the range -40 to $+85°C$.

COMPANIES

A NEW corporation, the **Clyde Williams Corporation,** to provide research, technical information, investment, advisory, and management services in the United States and Europe has been organised by Dr. Clyde Williams, Columbus, Ohio, and his American and European business associates.

A major purpose of the company is to provide liaison between European and American technology. Among other things the new firm is advising American companies where to place research projects. For this purpose, European nationals highly trained in research management will be attached to the London and Paris offices.

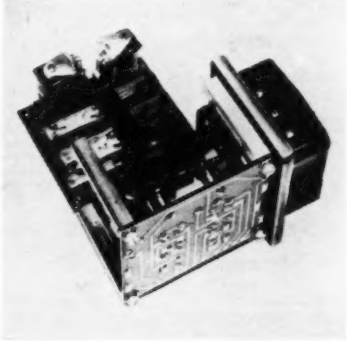
In the technical information field, the Clyde Williams Corporation is collecting engineering and technological data for its clients and provides special information relating to technical products, new production processes, equipment, company capabilities, patents, licence agreements and related matters.

Its market studies include analyses of the expected role of foreign companies in world markets, statistical investigations of existing and potential markets, sampling surveys of consumer purchasing habits and motivations, and studies of European Common Market problems.

Two new divisions of **Smiths** (S. Smith & Sons (England) Ltd.), the Aviation Division and the Kelvin Hughes Division, will be concerned respectively with the aviation and marine businesses previously carried on by several companies in the Smiths Group. The undertakings of the aviation and marine subsidiaries (including Kelvin & Hughes Ltd.) will be transferred to S. Smith & Sons (England) Ltd. This step marks the second stage in the integration programme initiated last year with the formation of Smiths Industrial Division.

As in the case of Smiths Industrial Division, Mr. Ralph Gordon-Smith is chairman of the Aviation and Kelvin Hughes Divisional Boards. Mr. L. A. Morgan is general manager of the Aviation Division. Deputy chairman of the Kelvin Hughes Division is Mr. G. S. Sturrock, and Mr. F. W. Bates is general manager.

Plessey Type 4 controller



Headquarters of the new Aviation Division will be:

Kelvin House,
Wembley Park Drive,
Wembley, Middlesex.

The new Kelvin Hughes Division will have its Administrative Headquarters at:

New North Road,
Barkingside,
Essex.

and Sales Headquarters at:

St. Clare House,
Minories,
London, E.C.3.

ELLIOTT BROTHERS (LONDON) LTD. has created an **Automation Analysis Department** within its Data Processing Group of Divisions. The purpose of this new department will be to evaluate data on the precise knowledge available of the true mathematical nature of industrial processes. A number of Elliott 803 computers have been installed in America, Russia and certain other eastern European countries, with the intention that when the true natures of the processes involved have been determined, the computers will take over their operational control. The Automation Analysis Department will now undertake the specialised studies involved in this kind of work in Britain under the leadership of Dr. L. C. Payne.

ELLIOTT-AUTOMATION LTD. announce that **La Thermostatique S.A.,** the French subsidiary of the Rheostatic Co. (itself a member of the Elliott-Automation Group) has now become a wholly-owned subsidiary of the Group. Recently it was announced that Elliotts had acquired a part of the minority share-holding in La Thermostatique by an exchange of shares in that company for Elliott-Automation ordinary shares. The Rheostatic Co. has now negotiated the purchase of the whole of the outstanding balance of the shares in La Thermostatique for cash, so that that company is now also a wholly-owned member of the group.

A NEW depot at Sandbach has been established by **Henry Sykes Ltd.** for the sale, hire and servicing of their range of pumps, winches and pile-driving equipment. In particular, the new depot will cater for the demand for "Univac" pumps in the Bolton, Manchester, Leeds, Derby, Stoke, Birmingham, Shrewsbury, and Liverpool areas. The address of the new depot is Henry Sykes Ltd., Cheshire Depot, Studd Green Works, Elworth, Sandbach, Cheshire. Telephone: Sandbach 986.

MR. P. R. MALLORY, of **P. R. Mallory and Co. Inc.,** of Tarrytown, New York, largest manufacturers of electronic components in America, is in this country to discuss with the board of the British company, **Mallory Batteries Ltd.,** production plans for the company's extensive plant at Crawley New Town which is to be opened shortly. This new factory has been planned so that Mallory can take the fullest advantage of any developments in Europe.

Circle **359** for further information

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EVANS ELECTROSELENIUM LTD

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SALES AND SERVICING AGENTS THROUGHOUT THE WORLD

As a result of the recent decision between Associated Electrical Industries Ltd. and Thorn Electrical Industries to merge their respective interests in the manufacture and sale of cathode ray tubes the combined companies have now commenced trading under their new name, **Thorn AEI Radio Valves & Tubes Ltd.**

THE Board of **Ultra Electronics Ltd.** have reached a provisional agreement with K.G. (Holdings) Ltd. to acquire for cash the entire share capital of its subsidiary, W.S. Electronics Ltd., for the sum of £125,000 approximately, the effective date of purchase to be 31st July, 1961.

It is the intention of Ultra Electronics Ltd. to continue the business of W.S. Electronics Ltd. as a separate entity within the group.

FURNASCOTE refractory coatings, formerly manufactured and marketed by Corrosion Ltd., of Southampton, will in future be manufactured and marketed by **Furnascote Ltd.,** working from 16/18 Malvern Road, Southampton—Telephone, Southampton 71347. As from 1st September, 1961, all enquiries and correspondence should be sent to the sales director, Mr. G. L. Barron, A.I.R.I. (Sc.).

THE **Solartron Electronic Group** have just completed the second phase of their expansion plans with the opening of their new headquarters at Farnborough, Hants. Three years ago Solartron moved into the first 50,000 sq ft of their site with about 200 people drawn from their Thames Ditton and Dorking units. With the opening of the new headquarters about 175,000 sq ft are in full operation employing about 1,000 people. Solartron plan to double this factory area by 1965 or 1966.

THE new headquarters and main manufacturing plant of **Adrema Ltd.** and its associated companies, including Bradma Ltd., are situated in Acton, and comprise six buildings, occupying 110,000 sq ft of floor space.

W. G. Pye & Co. Ltd., of Granta Works, York Street, Cambridge, announce that their telephone number has been changed to Cambridge 58866.

AGREEMENTS

Dowty Hydraulic Units Ltd. recently announced that they have signed a licence agreement with **Kayaba Industry Co. Ltd.,** of Tokyo, for the manufacture in Japan of Dowty hydraulic gear pumps and motors. Manufacture will commence immediately.

The countries for which exclusive selling rights have been granted are Japan, Formosa, Korea and Indonesia.

Elliott Brothers (London) Ltd. have negotiated with the **Office National d'Etudes et de Recherches Aeronautiques (O.N.E.R.A.)** of France a licence to manufacture and sell two gas analysis instruments of the paramagnetic type for determining the oxygen content in gaseous mixtures. Extensive applications have already been found in the control of furnace atmospheres in processes such as cement manufacture, porcelain kilns and steel founding.

EXPORTS

STANTON INSTRUMENTS LTD., manufacturers of precision, analytical, microchemical and thermo-recording balances announce that they have recently supplied and installed a 10 kg capacity **high precision balance** at the Bureau International des Poids & Mesures, Sevres, near Paris.

The Bureau, which is the world's standards laboratory for those countries which adhere to the International Metric Convention, is re-equipping its Mass Section during the next few years. The 10 kg balance is the first new high precision balance to be installed since 1910 and orders for further high precision balances have already been placed with Stanton Instruments Ltd., for delivery during the next two years.

The 10 kg balance mentioned above is of the conventional three knife edge design and is fitted with a special optical reading system. It will be used for the testing of larger weights and is expected to provide a precision of weighing of not less than 1 in 100 million.

Constructors John Brown Ltd. recently signed a contract worth nearly two million pounds with Polimex, the Polish Government Trade Organisation.

This contract is for the design, supply and installation of three tonnage oxygen and nitrogen plants which are to be used in the production of ammonia at Tarnow in the south of Poland. CJB engineers will supervise the erection and commissioning of the plants.

The plants will be completed successively within a period of about five years and they will have a combined output of nearly 1,000 tons a day of oxygen and more than 1,100 tons a day of nitrogen. For the purpose of ammonia synthesis the nitrogen must be exceptionally pure and must not contain more than 100 parts per million of other gases.

The air separation process used will be that developed in the U.S.A. by Hydrocarbon Research Inc., who will be closely associated with CJB in the technical aspects of the project. This process has already been used in U.S.A. and elsewhere in a number of plants of similar type, including the largest single tonnage oxygen units in the world, each producing 1,000 tons a day of oxygen.

DE HAVILLAND **Pottermeter flowmeters** have been chosen for use on a new 720 mile pipeline being built in north-east India. The pipeline will carry crude oil from the Assam oilfields to refineries in Gauhuti and Barauni (Bihar).

The Pottermeter uses a new principle in flowmeter design, in which a virtually friction-free rotor induces alternating currents in an adjacent coil; the frequency and number of the induced impulses specify the flow rate and quantity of fluid passing through the unit with very great accuracy.

De Havilland Pottermeters are already in service in seven countries—Australia, France, Germany, Holland, Italy, New Zealand, and Africa (the Sahara).

The equipment is manufactured in Britain, by de Havilland, under licence from the Potter Aeronautical Corporation of New Jersey, U.S.A.

Wayne Kerr Laboratories Ltd. have received their first order from abroad for a transfer function computer. It has been placed by Electricité de France, the French state electricity authority.

E.D.F. are engaged in the analogue computations of transmission line problems, and will use the Wayne Kerr S.A. 100 in a method that involves setting up the transfer function of line networks.

ELLIOTT-AUTOMATION LTD., as a part of its policy of expanding its export business, has created a new **Directorate of Overseas Operations.** The Group has ten operating subsidiary companies overseas and over a wide field of its operations exports more than one third of its products.

Mr. Keith Newlands, lately sales director of Cossor Radar & Electronics Ltd., has been appointed director of Overseas Operations.

METALON A.B. of Kavlinge, Sweden, have recently ordered another Camvac metalliser from **Vacuum Research (Cambridge) Ltd.** This plant is a compact reel-in-chamber high vacuum metalliser, which is particularly suited for the production of aluminium coated capacitor tape.

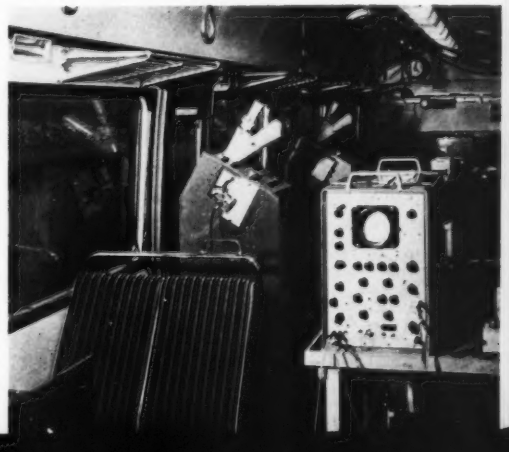
Dobbie McInnes (Electronics) Ltd., of Glasgow, have received an order valued at £8,500 from S.A.A.B. Aircraft Co. in Sweden for automatic graph plotting equipment to operate with the S.A.A.B. computer.

This makes the eighth order for plotting equipment received from Sweden.

THE Royal Swedish Air Force Board has placed with **Bristol Aircraft Ltd.,** a company of British Aircraft Corporation, an order for the Bristol/Ferranti Bloodhound Mark 2 surface-to-air guided weapon system, which will play a key part in the future of air defence of Sweden.

Servomex Controls Ltd. have sold 39 voltage stabilisers, a.c. and d.c., to the Institute of Physics at Helsinki University. This £5,000 order was negotiated direct with Professor Nurmia, who is re-equipping the Institute of Physics.

The Cawkell Remscope installed in the G.E.C. mobile laboratory used in research into problems affecting high voltage electrification on Eastern Region lines of British Railways



Servomex have also received an order from the Italian firm Sicedison, who have ordered four of the latest infra-red liquid analysers. The Servomex chemical instruments manager, C. R. Evans, will be supervising the start-up of these machines at the company's works in Venice.

AGENTS

THE Ambersil Division of **Amber Oils Ltd.** have appointed the following as agents and distributors of their aerosol packed products, Ambersil Formula One and Formula Two, Ambersil Electrospray and Ambersil M.S.4 silicone grease:

1. Scottish agents for all Ambersil Division products:

Young, Black & Co. Ltd.,
152 London Road, Glasgow, C.1.
Tel.: Glasgow BEL 1678.

2. Distributors of Ambersil M.S.4 silicone grease to the radio, television and electronics industries throughout England and Wales:

Direct T.V. Replacements Ltd.,
138 Lewisham Way,
New Cross, London, S.E.4.
Tel.: TIDeway 6666.

3. Distributors to the electrical industries of Ambersil M.S.4 silicone grease:

British Central Electrical Co. Ltd.,
Briticent House,
6 & 8 Rosebery Avenue, London, E.C.1.
Tel.: TERminus 3666.

Caselco Ltd.
Midland Works,
Canal Road, Leeds, 12.
Tel.: Leeds 630551.

T. J. Grainger & Co. Ltd.,
9-13 St. James' Street,
Newcastle, 1.
Tel.: Newcastle 24552.

Electrical Trade Supply Ltd.,
Loveday Street,
Birmingham, 4.
Tel.: Aston Cross 5671.

Holiday & Hemmerdinger Ltd.,
71 Ardwick Green North,
Manchester, 12.
Tel.: Ardwick 63668.

The Loughborough Glass Co. Ltd. has recently been appointed U.K. agents for the range of air sampling equipment manufactured by the Gelman Instrument Co., Michigan, U.S.A.

Air sampling equipment

Lancashire Dynamo & Crypto apprentices being shown round the air-conditioned zone, where meters are assembled, on their recent visit to Avo Ltd. The air-conditioned zone ensures that the air is free from dust which would affect the high standards required in the production of meter movements. The party is seen watching the assembly of jewelled bearings used in meters.

EDUCATION

J. LANGHAM THOMPSON LTD. are introducing a scheme of **industrial research fellowships.** These fellowships are being offered to young research workers of high calibre, normally on a two year tenure, with the intention that those appointed should carry out their research in the company's laboratories.

The fields of interest to the company include: solid state, cybernetics, logical systems, electronics, circuit techniques, microwaves, mechanics of solids, transducer techniques, optics.

The research worker will have the advantage of continuing his work under liberal conditions with freedom from restrictions, and at the same time allowing him to learn something of industry, its methods and problems.

THE **Bristol College of Science and Technology** is to equip its Department of Mathematics with a National-Elliott "803" electronic digital computer.

The "803", which will be installed in October, 1961, has provision for both punched-tape and punched-card input. It includes magnetic film file storage and an automatic floating-point arithmetic unit. The installation will enable students to acquire skill in all aspects of computing work and will provide members of the staff with a system fully capable of handling the wide range of computational tasks which they are likely to encounter in the course of their work.

The University of Manchester College of Science and Technology is planning to expand its Department of Industrial Administration. The first professor, R. W. Revans, was appointed in 1955 and is now being joined by Ronald Beresford Dew, M.A., LL.B., F.C.A., assistant managing director of Production-Engineering Ltd., who will take up a new appointment as first visiting professor in Industrial Adminstration in the University and in the College on 1st October, 1961.

The new appointment closely interprets the traditional policy of the College, namely, to build the academic subject upon operational studies of the relevant technology in industrial Manchester and elsewhere.

AMONG the new and revised schemes for the session 1961-62 the City & Guilds of London Institute have organised a course on **instrument maintenance,** full details of which may be obtained from: The City and Guilds of London Institute, 76 Portland Place, London, W.1.

ASSOCIATIONS

MUCH of the scientific work of **The Institution of Electrical Engineers** has been conducted by four specialised sections (Electronics & Communications, Measurement & Control, Supply and Utilisation).

The Council have decided that it will be advantageous for the four Sections to be replaced by three Divisions, two of which will represent "Electronics" and "Power" interests, while the third, a "General" Division, will cover activities of common interest to all electrical engineers, such as basic measurement, and technological education.

Each of the Divisions will comprise a number of technical groups designed to

Circle 360 for further information

Solid state electronics for Solid reliability

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Using only ferrite-core and transistor techniques in the counting circuits—

The Racal Type SA501A is a unique fully transistorized Universal Counter Timer utilizing transistor/ferrite-core techniques throughout. Ideally suited for industrial and laboratory applications alike, the instrument incorporates a fully variable digital time-base and in-line display.

- **Frequency Measurement 0 — 110 Kc/s**
- **In-line Display**
- **Variable Digital Timebase**
- **Transistor/Ferrite-Core Techniques**
- **Operates Remote Readout or Digital Printer**

A modified version of the SA501A is available designed specially as an Electronic Tachometer, for the direct measurement of engine speeds etc. This instrument, the Racal type SA502 incorporates the above features in a compact portable, battery-operated equipment.

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cover the specialisations within its field, and the scheme provides for speedy re-adjustment and creation of these technical groups which will increase the flexibility which is now more than ever necessary to reflect the rapid developments of electrical science and engineering.

THE **BEAMA Council** has established an Electronics Board to represent that part of the BEAMA membership directly concerned with electronic engineering. This new Board will act for the BEAMA Council on matters of broad policy in this field and it will provide the necessary high level liaison with Government Departments and other Associations on policy matters affecting the electronic industry. The initial membership of the Board is as fol'ows:

Mr. Leon Bagrit (Elliott Bros.)—*chairman.*
Mr. O. W. Humphreys (G.E.C.)—*vice-chairman.*
Mr. E. B. Banks (English Electric).
Mr. W. S. Steel (A.E.I.).
Mr. Sebastian de Ferranti (Ferranti Ltd.).
Mr. C. Metcalfe (E.M.I.).

The chairman of the BEAMA Industrial Electronic Equipment Section, at present Mr. W. Gregson (Ferranti Ltd.), is also a member of the Board.

These arrangements are designed to provide within the framework of the BEAMA an organisation to safeguard the interests of British manufacturers concerned with electronic engineering, but it is not intended to assume on behalf of BEAMA members responsibility for other sectors of the electronic engineering industry, e.g. telecommunications and components which are already dealt with by existing Associations. The Board will, however, co-operate with the governing bodies of such other Associations whenever policy matters affecting the electronic industry as a whole call for representations at top level.

THE following were nominated by the **Institution of Electrical Engineers** for the vacancies which will occur in the offices of president, vice-presidents, honorary treasurer, and ordinary members of Council on the 30th September next:

President (one vacancy):
G. S. C. Lucas, O.B.E., F.C.G.I.
Vice-Presidents (two vacancies):
A. H. Mumford, O.B.E., B.Sc.(Eng.)
R. L. Smith-Rose, C.B.E., D.Sc.,Ph.D., F.C.G.I.
Honorary Treasurer (one vacancy):
C. E. Strong, O.B.E., B.A., B.A.I.
Ordinary Members of Council:
Members (four vacancies):
Sir Robert Cockburn, K.B.E., C.B., M.Sc., Ph.D.
J. S. McPetrie, C.B., Ph.D., D.Sc.
Prof. C. W. Oatley, O.B.E., M.A., M.Sc.
H. West, M.Sc.
Associate Members (two vacancies):
J. Brown, M.A., Ph.D., D.Sc.(Eng.)
P. L. Taylor, M.A.
Companion (one vacancy):
The Rt. Hon. The Viscount Falmouth.

No other nominations having been received from members of the Institution, the Council's nominees are duly elected.

A MEETING of the **Polarographic Society** will be held on Wednesday, 25th October, 1961, at 2-45 p.m., at the School of Pharmacy, 29-39 Brunswick Sq., London, W.C.1. Prof. W. H. Linnell has agreed to take the chair, and Prof. Dr. M. von Stackelberg, of Bonn University, will read a paper (in English) entitled:

" Some Special Problems in the Polarography of Indium and Tellurium ".

He will be presented with the Society's medal for the current year.

AT the first Annual General Meeting of the amalgamated **Institute of Physics and The Physical Society** held in London recently, the following were elected to office:

President: Sir John Cockcroft.
Vice-Presidents: Dr. V. E. Cosslett, Professor R. W. Ditchburn, Dr. W. H. Taylor, and Dr. J. Topping.
Honorary Treasurer: Dr. J. Taylor.
Honorary Secretary: Dr. C. G. Wynne.

Eight ordinary members of Council were also elected. This, the first elected Council of the amalgamated body, is very nearly the same as the " caretaker " Council which has been in office during the first few months of the amalgamated body.

HER MAJESTY THE QUEEN has been pleased to approve the grant of a Charter to the **British Institution of Radio Engineers.** The Order in Council is dated 2nd August.

DR. D. G. CHRISTOPHERSON, O.B.E., F.R.S., pro-vice-chancellor of the University of Durham and Warden of the Durham Colleges, has accepted an invitation to give the first annual lecture of the **British Conference on Automation and Computation (B.C.A.C.).**

He will speak on the subject, " Mathematics—Friend or Foe? " at the Lecture Theatre of The Institution of Electrical Engineers, Savoy Place, London, W.C.2, on Wednesday, 27th September, at 5-30 p.m.

The lecture is open to all members of the 31 member societies of B.C.A.C.; others should apply for tickets (free) from the Honorary Secretary, B.C.A.C., c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

His Highness the Maharajah of Jaipur and Mr. Forbes, a director of Simmonds-Marshall Ltd., the Indian associate company of the Firth Cleveland Group, on a recent visit to the Solartron Electronic Group, are seen examining the X-ray fluorescent spectrometer together with Mr. Bolton and Mr. Binyon, of Solartron.

Some of the equipment displayed narrow boat "Taplow" which has bee verted into a waterborne showroom f products of Communication Systems "Taplow" will be undertaking a three- journey along the inland waterways will take her to most of the ind centres of the Midlands.

THE Department of Scientific and I rial Research have recently formed **National Lending Library** in or r to keep the British public informed on all aspects of Soviet science and technology. Russian technical progress is reported in the Department's Russian Translating Programme. 17 of the leading Russian technical journals are translated into English and published each mon y British research associations and sc tific societies for the Department.

The Department also sponsors the translation and publication of Russian technical books, as well as having the facilities for the loan of individual translations. These are obtainable from the National Lending Library for Science and Technology, Boston Spa, Yorkshire.

EXHIBITIONS, CONFERENCES, ETC.

THE INSTITUTE OF PHYSICS and The Physical Society announce that a residential symposium on **" Some aspects of the physics of space research "** will be held at the Royal Military College of Science, Shrivenham, Swindon, Wiltshire, from 20th to 22nd September, 1961. The subjects to be discussed are: the advantages to physicists of space research;

cosmic rays, particle physics and meteorology; radio research from rockets and satellites; and rockets, orbits and trajectories.

A TWO-DAY conference organised by The Institute of Physics and The Physical Society in collaboration with the British Radio Spectroscopy Group on **"Radio-spectroscopy of solids"** will be held in the Department of Physics of the University College of North Wales, Bangor, on 21st and 22nd September, 1961.

The Institute and Society's Guthrie lecture will be presented during the conference by Dr. D. Shoenberg, F.R.S., who will speak on:

"The de Haas–van Alphen effect and the electronic structure of metals".

THE INSTITUTE OF PHYSICS and The Physical Society are to hold a one-day symposium on **"Some aspects of vacuum science and technology"** at Imperial College of Science and Technology, London, on 5th January, 1962.

The scope of the symposium will be: (a) continuously exhausted bakeable vacuum apparatus for pressures below 10^{-9} mm of mercury and (b) the controlled deposition of evaporated film.

Further details and application forms will be available about the end of October, 1961, from the Administration Assistant, The Institute of Physics and The Physical Society, 47 Belgrave Square, London, S.W.1.

THE Board of Trade is providing an official United Kingdom exhibit and organising a large commercial display of ... products at the **Indian Industries** ... the international trade exhibition in Delhi, which will be held from 14th ...mber—1st January, 1962. The ...d Kingdom Pavilion will be in two ...or sections. The first is to be devoted ... official exhibit, "Britain: India's ...rial Partner". The object of this ... will be to outline Britain's con... contribution to the industrialisa... India and will include sections on ..., transport, communications, pow..., industrial production, health and knowledge. This section will lead into the commercial display, filling the second section, in which British firms and Indian firms with British connections will stage individual displays of their products.

... first **International Congress on Chemical Machinery, Chemical Engineering and Automation** will be held in Brno, Czechoslovakia, from 3rd—8th September, 1962, just before the IVth International Trade Fair.

Original scientific contributions will be presented by authorities in these fields. Simultaneous translation will be provided into English, Russian and German.

Griffin & George Ltd. are staging two exhibitions, one in Cardiff and the other in Manchester, at which laboratory equipment will be shown.

They will be held in the Welsh College of Advanced Technology, Cathays Park, Cardiff, from 12th—14th September inclusive, and at the Chorlton Town Hall, Cavendish Street, Manchester, from 18th—21st September inclusive.

THE 4th Congress of the **Federation of European Petroleum Equipment Manufacturers** (Fédération Européene des Constructeurs d'Equipment Petrolier) will be held from 25th—28th June, 1962, at Church Hall, Westminster. Approximately 20 technical papers covering automation, new corrosion-resistant materials, temperature insulation, aircraft refuelling and future trends in the design of drilling equipment for the petroleum industry will be presented.

A JOINT **International Conference on Creep and Fracture** will be held in New York from 25th—28th August, 1963, and in London during October, 1963. The sponsors are the American Society of Mechanical Engineers, The Institution of Mechanical Engineers and the American Society for Testing Materials.

The Conference will be devoted to the mechanical properties of engineering materials at elevated temperatures; the emphasis being on the utilisation, by the mechanical engineer, of creep and rupture data on current materials in the design of equipment to be used at elevated temperatures.

AN exhibition organised by **Wolsey Electronics Ltd.** will be held on the 1st floor of 39/41 New Oxford Street, above Grundig (Great Britain) Ltd.'s showrooms from 18th—22nd September. The exhibition will demonstrate the flexibility of Grundig closed-circuit television equipment. Included in the display will be internal closed-circuit operation, long distance operation using a zoom type lens, and a camera will also be used in conjunction with film projection for telé-ciné equipment. Various selected units of the Grundig instrument range will also be shown.

MANUFACTURERS' LITERATURE

Contact Fingering

The latest literature, published by the Sealectro Corporation, is a four page leaflet dealing with a new range of contact fingering which is available in many variants of finger lengths, width and pitching.

Typical uses include connections to the electrodes of co-axial and external anode type valves, wave-guide contacting, door bonding in screened rooms or cabinets and r.f. ovens.

Circle **68** *for further details.*

Miniature Electronic Components

The 1961 issue of the Ardente Miniature Component Catalogue contains full details of the company's range of miniature rotary switches now available with sealed spindles, Ministry Departmental Approval, and with a spring return action. The range of standard transformers has been increased and a new miniature power transformer, the D 8000 series, introduced.

Typical specifications together with mechanical and electrical details are included.

Circle **69** *for further details.*

Industrial Containers

A four page supplement has just been published by KABI (Electrical & Plastics) Ltd. to their catalogue of bench assembly trays, storage, handling and transit containers.

Circle **70** *for further details.*

International Rectifier Co.

The International Rectifier Co. have recently published a new short form catalogue and price lists. Several new products have been added to their range and these include: the miniature 200 mA glass diodes; the 5A series of encapsulated diffused rectifiers rated at 1 amp and the X10B series of diffused top hat rectifiers rated at 1·3 amp.

Details are also given of the 5 amp silicon controlled rectifier, available up to 400 p.i.v.; the QV series of 250 mW glass Zener diodes, which are available in $\pm 5\%$ and $\pm 10\%$ tolerance in voltages ranging from 27·0 V down to 3·3 V and the new 1N429 reference element.

Circle **71** *for further details.*

Duraglas

The properties of Duraglas are described in booklet D.6, entitled *Glass Fibre Reinforcements*, published by Turner Brothers Asbestos Co. Ltd. Details of woven fabrics, tapes, chemically and mechanically bound mat, woven roving, roving, chopped roving, flock and webbing are included together with illustrations of some recent fabrications made from Duraglas glass fibre reinforcements.

Information is given of the company's advisory service and there is a pocket at the back of the booklet containing specification and price sheets.

Circle **72** *for further details.*

Power Supplies

Leaflet No. 6010/1 from Claude Lyons Ltd. give details of Type PSS-32/50 stabilised d.c. power supplies. Two standard models are available, each having a continuous output current rating of 50 A. Type PSS-32/50-A has an output voltage range of 24-32 V d.c. in one continuous range; Type PSS-32/50-B provides an output range of 20-32 V d.c. in two overlapping ranges of 20-28 V and 24-32 V.

Specifications are included.

Circle **73** *for further details.*

Molytherm Grease

Publication No. 17, available from Rocol Ltd., describes Rocol molytherm grease, which has been designed specially to provide lubrication for industrial plant and machinery at a higher range of temperature than that of other high temperature greases.

Circle **74** *for further details.*

(*Continued on page* 1178)

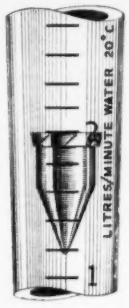
Circle **361** for further information

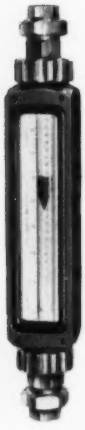
ROTAMETER

FLUID MEASUREMENT AND CONTROL

FLOW-DENSITY-LEVEL

A typical glass tube and float





Type 900 Metric series (for non-corrosive service)

Type 907 Metric series

FLOW MEASUREMENT

The Rotameter type of variable-area flow-meter is applicable to most of the flow measurement problems which arise in industry and research.

It is particularly useful in the chemical industry because it can be constructed in a variety of corrosion-resisting materials.

When the working conditions are appropriate the direct-reading glass-tube Rotameter is a first choice on account of its inherent simplicity. For work which requires high accuracy it may be calibrated individually for the fluid which has to be handled, or if a lower degree of accuracy can be tolerated an instrument chosen from the interchangeable "Metric" series shows advantages in respect of lower cost and quick delivery. The new mountings, Type 907 and 914, offer, in addition, interchangeable gland packing, including P.T.F.E., with robust corrosion-resisting structural parts.

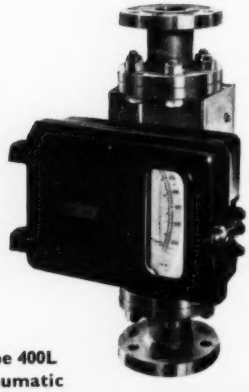
Glass-tube Rotameters are used to measure flows between:

2 ccs/Min and 2,600 L/Min of gases or between:

0.5 cc/Min and 225 L/Min of liquids.

Rotameters are also made in which the tapered metering tube is of metal. These may be direct reading, or they may have transmitting mechanisms (electric or pneumatic) giving signals which will operate recorders or controllers. Some designs will work at high pressures and temperatures (e.g. 5,000 p.s.i.g. or 500°C.).

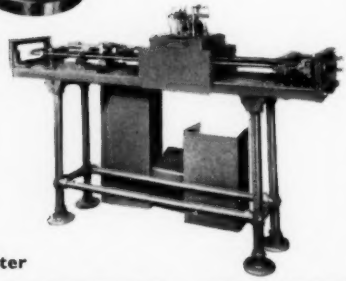
A large metal-tube Rotameter will measure liquid flows up to 5,000 L/Min. Several types of alarm are available to signal changes in flow beyond desired limits.



Type 400L Pneumatic Transmitting Rotameter with lagged body

LIQUID DENSITY MEASUREMENT

The "RM" Density Meter provides a continuous indication of the density of a liquid flowing through it, this indication taking the form of either an electric or a pneumatic signal which can be displayed upon an appropriate instrument. It will handle most corrosive liquids and is particularly successful in dealing with muds and slurries (lime, china, clay, etc.).



The "RM" Density Meter

At the maximum sensitivity, full-scale deflection corresponds to a density change of 0.025 gm/ml—enabling density changes of the order of .00025 gm/ml to be detected—and compensation for changes in process temperature can be applied.

On account of its small measurement lag, the "RM" Density Meter gives excellent results in automatic density control systems.

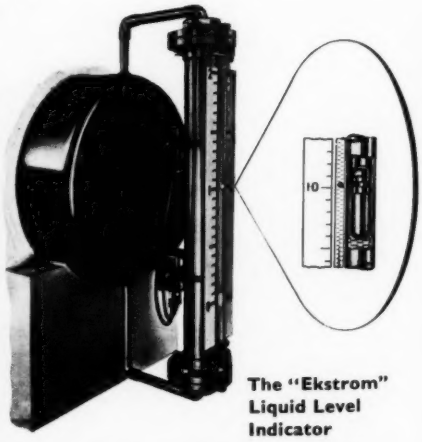
"EKSTROM" LIQUID LEVEL INDICATOR

The "Ekstrom" level gauge consists of a tube of non-magnetic material (e.g., stainless steel) containing a magnetised float which rises and falls with changes in the liquid level. Adjacent to this is a glass tube in which is a hollow iron ball immersed in butanol. The ball forms in effect a weightless pointer and follows the movements of the magnetised float.

Accidental breakage of the glass indicator tube does not involve any loss of plant fluid, and the "Ekstrom" level gauge is, therefore, suitable for use on tanks containing dangerous or corrosive liquids.

These gauges can be supplied to work for most liquids, and are often made to cover level changes of 18 feet. They can be provided with magnetically-operated electric or pneumatic switches for high or low level alarm purposes or for pump control.

Catalogue I.P.2000/1 is available on request.



The "Ekstrom" Liquid Level Indicator

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PURLEY WAY · CROYDON · SURREY

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INSTRUMENT APPLICATIONS

Army Pay Accounting

An IBM 705 is now processing the accounts of soldiers in the Army. This computer is housed in the new headquarters of the Royal Army Pay Corps at Worthy Down, near Winchester, and the change from manual to electronic accounting will save between 500 and 600 men and £400,000 a year.

A feature of the electrical services is the need for frequency-changing equipment to supply the computer at 60 c/s. For this purpose, a Crompton Parkinson motor generator set has been installed, comprising a 250 kVA, 208/122 V, 3-phase, 60 c/s alternator operating at from 0·7 to 0·9 power factor, directly driven at 600 rev/min by a 325 hp auto-synchronous 415 V motor, together with the composite main airbreak switchboard and control panel.

In order that the computer may operate correctly a stable frequency is essential, and this control panel for the motor generator set contains, in addition to other instrumentation, 4 indicating frequency meters on both the 50 and 60 c/s circuits and a recording frequency meter on the incoming supply. The latter is a George Kent "Multilec" instrument, designed for a working range of 47 to 51 c/s and possessing an accuracy over the whole range of ±0·003 cycle. A record of the frequency is maintained by a 10 in. wide strip chart recorder capable of being run at 3 speeds, preselected by a gear-box. The output voltage is governed to within ±1% by a Brown Boveri automatic voltage regulator of the rolling sector pattern. A duplicate standby motor alternator set will be installed shortly.

Besides the pay work, the computer will also be used to produce the results of the U.K. National Census that is being undertaken this year and will save several years in the publication of the final results. A job that formerly took about eight years to complete will now be finished in about three.

Data Logging and Remote Control System for Basrah Petroleum Company

An important part of a system for remote control and data logging of oil pipeline degassing stations supplied by Automatic Control Engineering Limited to the Basrah Petroleum Company was the telemetering and data logging equipment manufactured by Standard Telephones and Cables Ltd.

There are four degassing stations, at Rumaila, Qurainat, Shamiya and Janubia. The control centre is to be sited at Rumaila, but this degassing station is being treated as a remote station, exactly like the other three.

Control and data transmission is over pilot pairs in 20 lb/mile multiconductor telephone cable. The transmission of controls and alarm indications is carried out at telephone dialling speed whereas data transmission is at telegraph speed, i.e. 50 bauds.

The facilities provided at the control centre for each outstation are:

(a) Telephone communication between outstations and control centre.
(b) Raise/lower pipeline flow—simultaneous control for all pumps.
(c) Emergency shut-down.
(d) The logging of the following data:
Oil level, tanks 1 and 2.
Main Oil Flow.
Main Oil Pressure.
Temperature, turbines Nos. 1, 2, 3 and 4—giving a total of eight data displays for each outstation.
(e) Three alarm indications.

At the control centre all data are displayed continuously by illuminated digital indicators. These readings are printed out on a Creed 75 teleprinter once an hour, or whenever an instantaneous print-out is requested by the engineer-in-charge.

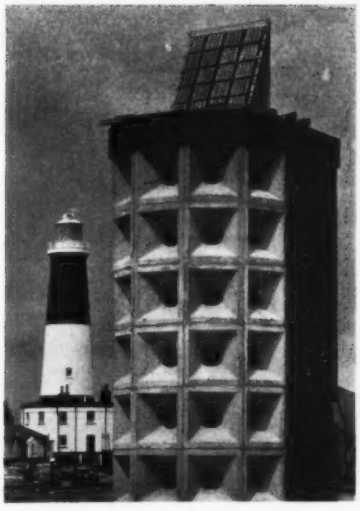
The equipment incorporates an analogue-to-digital converter at each degassing station and the analogue information is presented to this in turn in the form of a variable resistance for each parameter to be logged. The basic converter circuit is a decade resistance bridge which balances automatically in two stages of coarse and fine adjustment, representing respectively tens and units of the ultimate percentage to be transmitted.

This means that only 20 logical steps have to be made at most to balance the bridge whereas 100 steps would be necessary if a single range were used.

Upon receipt at the control centre, the data are translated from the percentage form into practical units before display (e.g. barrels per day, lb/sq in. etc.).

For calibration and testing, the various parameter resistors at the outstation can be replaced, upon receipt of a request signal from the control centre, by known fixed-value resistors. This provides a spot check on the accuracy of the system.

The data system is fully transistorised, using no thermionic valves or cold cathode tubes. For greater reliability, wrapped wiring techniques are used instead of soldered joints. Most of the circuits are built up on small plug-in "group" boards, which are of standard design, allowing the speedy replacement of any board from a stock held by the station engineer.



Installation showing 400 solar cells situated at the Corporation of Trinity House experimental establishment at Dungeness, Kent

Solar Cell Installations for Marine Buoy Lighting

In the next few years it seems likely that silicon solar cells will be widely employed to provide power for re-charging batteries for marine buoy lighting.

Considerable efforts are currently being made in this direction by research engineers of Trinity House and already a number of experimental installations have been built both at Trinity House and at their research station at Dungeness, Kent.

At present marine buoy lighting relies almost entirely on the use of stored gases, such as propane or acetylene, the gas being used not only to provide the light, but also to control the character of the flash. Systems like this have been in use for many years and have proved extremely economic and efficient. It is necessary, however, to replace the gas cylinders, often under adverse weather conditions, at an interval of approximately 12 months.

With the advent of the silicon photovoltaic cell, or, as it is more commonly known, the solar cell, which converts energy from the sun or from incandescent lamps into electrical energy, Trinity House research engineers turned their attention to its possible application to marine buoy lighting. They recognised that the use of the solar cell would be advantageous, particularly from the maintenance viewpoint, because of its extreme reliability. Indeed, there appears to be no special reason why such a cell should ever fail and experiments carried out by the manufacturers, Ferranti Ltd., bear this out, for over a period of 20,000 hours there is no evidence of change in the device. It has a response time of a few

microseconds and can operate without deterioration under conditions of high temperature (−40 to +125°C) and humidity.

In their planned programme of research, which is of necessity long-term in nature, Trinity House research engineers have already established practically that despite the unfavourable English climate, solar cell installations can provide the necessary power throughout the year to charge a small battery. However, because of the many problems still to be solved, they do not anticipate that the first fully equipped marine buoy installation can be available for operation before the end of 1963.

Experimental equipment which has already been built takes the form of a spherical glass bulkhead type fitting in which a block of four Ferranti MS 11E silicon solar cells, wired in series, are mounted at an angle of inclination of latitude +15°. This ensures that a maximum charge is given to the 1·2 volt NIFE storage cell throughout the year. In peak sunlight conditions the maximum daily charge is of the order of 250 milliampere-hours. Each cell provides about 0·4 V on load.

The NIFE storage cell, which will be mounted in the well of the completed buoy, will be of the nickel-iron, alkaline type, with a capacity of 45 ampere-hours. It will not only provide the power to operate either a low-wattage electric filament lamp or xenon flash tube during the hours of darkness, but will also operate a transistor coder to give the light the desired character for identification purposes. At daybreak, a silicon light-sensitive cell will switch off the coder and the light. When darkness falls some means must be introduced to prevent the battery then discharging back through the solar cells. This is usually achieved by using a backing-off diode in each of the parallel arms of the cells.

There are still a large number of major problems to be overcome before the first fully equipped marine buoy installation becomes a reality. These include the effects of buoy motion, prolonged periods of little or no sunlight—although the solar cell does not require direct sunlight for its operation—and the more pratical problem of preventing sea birds from fouling the surface of the solar cells, thereby reducing their efficiency.

With the knowledge already accumulated by Trinity House, these problems can be solved and research work at present being undertaken should ultimately lead, not only to solar-powered navigation lights, but also other solar powered aids to navigation.

Teleprinter network for the Aluminium Ltd. of Canada Group of Companies

A MAJOR private-wire teleprinter communications system has been placed into service in the United Kingdom by the Aluminium Ltd. of Canada (Alcan).

Supplied by Creed & Co. Ltd., the new system provides high-speed, accurate, two-way communication between 24 offices of Alcan and its associates, and is designed initially to handle several thousand business messages weekly, while having built-in capacity for future expansion. It also connects, via the transatlantic cable, with the Montreal centre of Alcan's extensive North American teleprinter network, bringing the widespread facilities of the organisation on both continents within minutes of each other for integrated up-to-the-minute operational control. Alcan teleprinter installations now being planned by Creed and its Associates in several European countries will later be linked with the United Kingdom network, and, through it, to the N. American complex.

The new Creed teleprinter system consists of a tape relay message centre located in Aluminium Canada House, Berkeley Square, W.1, Alcan's London headquarters, which is directly linked by G.P.O. private-wire circuits to six area groups in different parts of the country, each group comprising up to six local offices.

This action signals the local group switching unit that a message awaits attention and transmission proceeds automatically at a continuous 66 words per minute as soon as the call is accepted. The outgoing signals received by the switching unit are also transmitted back to the station's Model Seventy-five teleprinter which provides a page print-out of the message, confirming reception by the switching unit and furnishing a copy for checking and record purposes.

Should another station in the same area group already be sending or receiving, the tape in the transmitter will not feed through the machine until the switching unit is free. Apart from the stationary tape, a further indication that the switching unit is busy is provided by arranging for each local office's Model Seventy-five teleprinter receiver to print out the address details of messages transmitted by all the others.

Messages are handled one at a time, the unit in effect "asking" each station in turn whether they have a message to send, but always checking first with the main relay centre to ensure that incoming messages from other area group offices automatically receive priority.

All offices in the network have a set of message originating, sending and receiving equipment comprising a Creed Model 7 P/N keyboard perforator and Model 6S/6-M automatic tape transmitter, mounted side-by-side on an equipped desk unit, together with a Creed Model Seventy-five teleprinter receiver, separately mounted.

Messages to be sent are encoded in five-track punched paper tape by off-line typing on the perforator keyboard, the operator inserting in front of the message a short series of pre-determined code signals indicating the destination required, i.e. the address. The leading end of the tape is then put into the automatic transmitter and a desk "call" button pressed.

The code symbols punched at the beginning of the tape are read by the group switching unit which automatically routes the message to its destination in another local group office or to the London centre as the case may be.

Inter-group messages switched through to the relay centre arrive there on a series of six Creed Model 86 printing reperforator receivers housed in two metal consoles. These machines code-punch the incoming message and also print a plain language interpretation on the tape for speedy identification.

A relay centre attendant simply notes the final destination of the message, tears off the completed tape and transfers it to the outgoing section. Since that part of the address code which caused the message to be routed initially to the centre is no longer required, it is torn off, leaving just the final destination code punched in the tape.

Two Creed Model 71 three-ring transmitters are employed in the outgoing section of the centre, both of which machines have three message transmitting heads, one for each of the circuits radiating out to the six area groups.

After putting the tape in the appropriate transmitter head, the operator presses a button, setting up the "call" condition. Transmission proceeds automatically immediately the call is accepted, the distant electronic switching unit routing the message to its final destination to be received there in printed page form on the Model Seventy-five teleprinter receiver.

pH Monitoring Equipment

FOR the heating of degreasing, de-rusting, and parkerising tanks at Marshall Motor Bodies Ltd., a closed-circuit heating system is employed. The fracture of a steam heating coil allowed parkerising solution to return to the boiler with the condensate return water. This caused heavy deposits to form on the boiler tubes resulting in a complete loss of boiler efficiency.

The approximate cost of complete loss of production for 50 days was £10,000, and the approximate cost of complete overhaul of the boiler, including replacement of boiler tubes, was £7,000.

To prevent any recurrence of this costly breakdown, Pye industrial pH equipment was installed to monitor continuously the pH value of the boiler condensate return water before its return to the boiler make-up tank. Within seconds of a heating coil fracture and entry into the heating system of process solutions, the pH sensing element measures the resultant change in pH value and immediately diverts contaminated return water to waste, at the same time operating a warning signal.

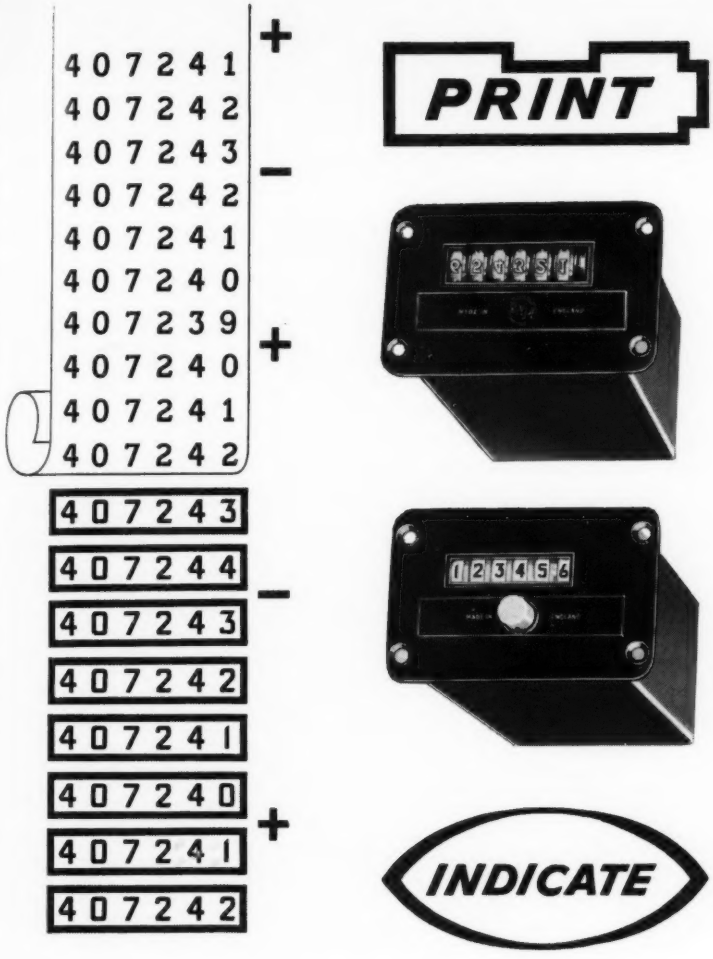
During the past twelve months of plant operation two coil fractures have occurred. In each instance contaminated condensate return water was automatically diverted to waste, preventing serious boiler damage.

(*Continued on page* 1176)

Quite a Difference

IN our July issue, the advertisement for the miniature needle valves of F. J. Hone & Co. Ltd. wrongly stated the size to be 1 in. This should have read $\frac{1}{8}$ in.

Circle **362** for further information



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Optional Features Include — *Add only, Subtract only or Add and Subtract Models — Operation on AC or DC — Electrical or Manual (push button) reset — Standard and High Speed models with counting rates up to 3000 impulses per minute — Service life in excess of 10^8 impulses —*
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Leading Manufacturers of Counting and Numbering Devices

Circle **363** for further information

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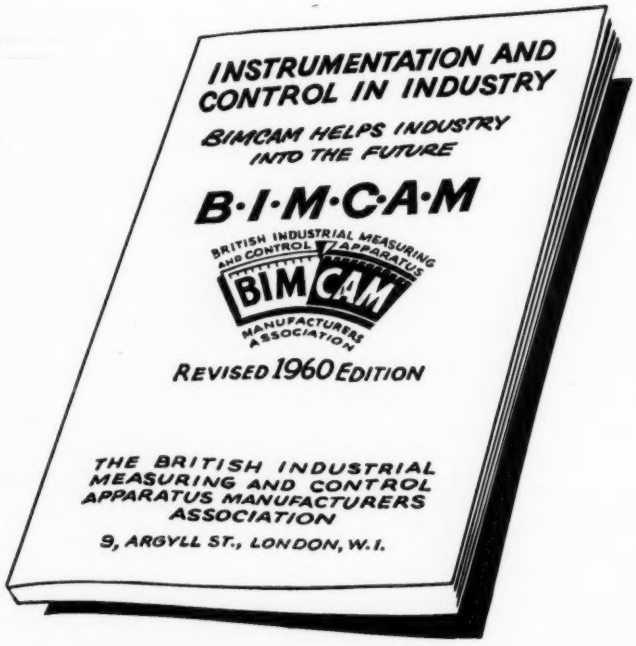
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Mr. T. J. R. Smith

Mr. J. D. Percy

Mr. B. W. Morgan

Mr. A. R. Enshaw

PERSONALITIES

Mr. G. D. Taylor

The Rt. Hon. the Earl of Halsbury has been elected president of the Machine Tool Industry Research Association.

Lord Halsbury is well known for his work on the application of scientific research, and has many connections with the machine tool industry. From 1949 to 1959 he was the first managing director of the National Research Development Corporation and in this capacity was associated with machine-tool research at the Manchester College of Science and Technology.

Dr. Sydney Jones has joined R. B. Pullin & Co. Ltd. as technical director. This appointment follows the company's decision to ensure the enlargement of its activities throughout the whole field of electronics, electrics, electro mechanics, etc.

Dr. Jones was until recently director of research applications at the Central Electricity Board, where he was responsible for the development of forward-looking research projects. In particular, he was responsible for the development of automatic process control systems.

The Plessey Co. Ltd. have appointed **Mr. A. Robert Enshaw** as executive director in charge of its Government Contracts Department. Mr. Enshaw, who until this appointment was manager of the company's Telephone Apparatus Department, joined Plessey in 1946. He has been active in the field of contract work for the Post Office and in the affairs of the Telecommunication Engineering and Manufacturing Association.

Hellermann Ltd. have appointed **Mr. T. J. R. Smith** as executive director.

Mr. Smith will now be responsible for the exclusive handling of all Government, Ministry and Post Office Departments, including the Admiralty, Army and Air Force.

Dr. Wilfred F. Coxon, M.Sc., Ph.D., has been appointed to the board of C. P. Wakefield Ltd., advertising agents, as co-managing director in conjunction with Mr. R. J. Wakefield.

Dr. Coxon will be primarily responsible for a newly formed industrial division which will specialise in industrial and technical advertising accounts.

The directors of Dynatron Radio Ltd. have appointed **Mr. W. G. Harrison** as director and general manager.

Mr. Harrison joined Dynatron three years ago as sales manager and for the past year has been general manager.

Mr. H. C. H. Matthews, B.Sc., A.M.I.E.E., has been appointed a technical director of Pantak Ltd., of Vale Road, Windsor, Berks.

Mr. D. H. Maxwell has recently been appointed transmission division sales manager of Telephone Manufacturing Co. Ltd.

In his new position Mr. Maxwell is responsible for co-ordinating and controlling all aspects of TMC's transmission sales activities.

Mr. P. E. Groom, credit manager of the Ekco Group of companies, retired at the end of July after over 27 years' service, during which he has made many friends in the radio trade. He entered the radio industry in 1927 and joined E. K. Cole Ltd. in 1933. Mr. Groom will be succeeded by **Mr. W. A. MacArthur,** who joined E. K. Cole Ltd. in 1949 and graduated through the sales departments to the position of assistant credit manager in 1958.

Mr. J. D. Percy has been appointed technical sales manager of Cossor Radar & Electronics Ltd.

Mr. Stafford Beer, who has been head of the United Steel Companies' department of operational research and cybernetics since its inception in 1957, has resigned to become managing director of a new international firm of operational research consultants. **Mr. David Owen,** previously assistant head of the department, has succeeded Mr. Beer.

British Insulated Callender's Cables Ltd. have appointed **Mr. J. Large,** Winding Wires Divisional manager, as general manager, Winding Wires Division. He will be responsible to Mr. E. Bowyer, executive director, for the administration of the division and the operation of the Huyton Quarry, Melling and Bessbrook (Northern Ireland) factories.

Two additional sales engineers have recently been appointed by Polypenco Ltd. These are **Mr. Jack Brunwin,** who has been made representative for the Southern Counties, and **Mr. John Palmer** the East and West Midlands.

Rank Cintel Ltd. have appointed **Mr. W. E. Taylor** as assistant manager of their Electronic Tube Division. Mr. Taylor has been connected with the electronics industry since the 1940's and prior to joining Rank Cintel was with A.E.I. as sales manager of their industrial Valve Department.

The Wayne Kerr Laboratories Ltd. have recently appointed **Mr. B. W. Morgan** sales engineer for North West London and surrounding areas.

Mr. G. D. Taylor, formerly head of the Flight Research Department of the Bristol Aircraft Company at Filton, has joined Epsylon Industries Ltd., as chief applications engineer.

Due to pressure of other business commitments, **Sir Peter Roberts, Bart., M.A., M.P.,** has resigned from the board of Staveley Industries Ltd.

Mr. Leslie Holdbrook has joined West Instrument Ltd. and will represent the company in N.E. London, Essex, Suffolk, Cambs., and Norfolk.

Mr. Bernard Feltbower, who joined The English Electric Co. two months ago, has been appointed chief engineer of the company's Control Gear Division at Kidsgrove, Stoke-on-Trent.

The George Cohen 600 Group Ltd. have appointed **Mr. Peter Bonner, B.Sc., A.M.I.Mech.E., A.M.I.Prod.E.,** to the board of their associate company, T. C. Jones & Co. Ltd., Structural Engineers, of London and Treorchy, South Wales.

Mr. E. J. Aaronson, F.C.A., has been appointed general manager, Overseas Operations of the General Electric Co. Ltd. of England. He was previously economic and financial advisor (export).

Mr. Laurie Woodhead, director and general manager of Cossor Instruments Ltd. and past president of the Scientific Instrument Manufacturers' Association of Great Britain, has accepted the chairmanship of the Organising Committee of the International Instruments, Electronics and Automation Exhibition, owing to the recent death, in Switzerland, of Mr. Philip Canning, the chairman.

Mr. Robert J. Hughes has been appointed chief editor of the training systems division of U.S. Industries, Inc. (Great Britain) Ltd. and will be responsible for setting up the first European programming department for U.S.I.'s newly-introduced teaching machine, the Mark II AutoTutor.

Mr. W. C. C. Turner, formerly of Crompton Parkinson Ltd., passed away on 23rd July, 1961 in his 82nd year.

He commenced his employment with Crompton & Co. at Chelmsford in 1898 and after completion of his apprenticeship he was appointed arc lamp specialist, a position which he held until the outbreak of the first World War.

In 1918 he took charge of Instrument Sales, combining the function of salesman and technical adviser, particularly to educational establishments to whose interests he devoted the majority of his time prior to his retirement. Although he officially retired in June, 1940, he gladly made his services available in an advisory capacity until 1959 when failing health forced him to curtail his activities.

(*Continued from page* 1172)

Photomultiplier Tubes Aid Steel Manufacture

MODERN steel furnaces can produce a "charge" of steel in ten minutes, but a chemist takes anything from an hour to a day to analyse a sample of the charge by wet chemical analysis. If the analysis then shows the composition to be incorrect, the charge has to be scrapped and the whole tedious time-wasting cycle begun again.

Hilger & Watts Ltd. has recently introduced the Polyvac-12 direct-reading vacuum spectrograph for the rapid automatic analysis of carbon, phosphorus, sulphur, manganese, silicon and other elements in steel. It can determine eleven elements in less than three minutes—considerably faster than a photographic spectrograph. The sample can be analysed and verified or corrected, before the charge is poured.

Polyvac has four parts—a source unit, a polychromator, a console and a vacuum pump. The polychromator, in its simplest version, accommodates up to 12 photomultiplier tubes, supplied by EMI Electronics Ltd. For more complex analyticai requirements, a modified spectrometer fitted with up to 20 photomultiplier tubes can be used.

Polyvac was designed as a vacuum spectrograph so that the far ultra-violet should not be absorbed by the oxygen in the air.

It is a fully automatic instrument. The sample is mounted on a discharge stand and the start button pressed. Less than a minute later, the read-out system begins to present a series of results on a meter, recorder or typewriter. The analysis of plain-carbon or low-alloy steels is presented in 75 seconds. A rate of working of 130 samples—each sparked in duplicate—per eight hour shift can easily be achieved.

The sample is sparked in a small chamber, where it acts as an electrode. Its light enters the spectrometer and is dispersed into a spectrum. The spectral lines of interest are isolated and their light sent to the EMI photomultipliers by small mirrors.

The outputs of the photomultipliers are stored in capacitors, and the potentials of the capacitors are measured in turn at the end of the exposure.

Computers used for Packing Case Design

ELECTRONIC computers have been used to help design special packing cases in which Short Seacat ship-to-air guided missiles are transported.

The packing case had to be capable of withstanding severe bumps, due to drops from a specified height, without damage to the missile or its instruments.

By using Short analogue computers, Short Brothers & Harland Ltd., manufacturers of Seacat, were able to test the efficiency of many packing case designs before the cases had actually been built.

Shock-absorbent mounts were designed to support the missile inside the case and a programme to test their efficiency was begun.

This problem, treated in the conventional manner, would have entailed the consideration of various mounting schemes and tests with different shock-absorbing fittings, but simulation with a Short general purpose computer greatly reduced the development and testing period. Electronic circuits were set up to represent the physical properties, such as stiffness and damping ability, of the mounting system's components. When an electric current, representing the velocity the case would have on hitting the ground, was fed into the circuit output currents were produced which represented the movements of the missile under the force of the shock. In this way full information was obtained showing how far selected points on the missile travelled, the speed at which they moved and the acceleration undergone.

The simulation technique, although used for a guided missile in this case, can be applied to the problems of safely packaging almost any valuable object.

Automatic Treatment of Semi Conductor Device Process Effluent

DURING semiconductor device processing considerable quantities of effluent are produced. This effluent is made of hydrofluoric, acetic, and nitric acids of varying composition, together with water-miscible solvents and large quantities of process water. The pH value of the effluent can vary between 0·5 and 5·0 and have a biochemical oxygen demand of approximately 2,000. At the recently completed plant constructed for the Texas Instrument Company at Manton Lane, Bedford quantities of up to 74,000 gallons a day with peak flows of 7,000 gallons per hour are continuously and automatically treated before disposal into the Local Authorities drains.

Treatment of the effluent comprises a single stage chemical treatment followed by settling of solids and a final biological treatment. The effluent is first collected in two 3,000 gallon balancing tanks from which it is pumped under level control into a 1,500 gallon treatment tank where lime slurry is added under pH control. Precipitation of solids takes place most effectively at pH values between 7·5 and 8·0 and Pye industrial pH measuring equipment coupled to a Taylor pneumatic controller adjust the rate of lime slurry addition to maintain these optimum conditions.

From the treatment tank the neutralised effluent is passed through a large settling tank where the suspended solids, mainly in the form of insoluble calcium fluoride, are removed. The final biological treatment, where the water-miscible solvents are reduced to an acceptable level, precedes a final pH check. As the clarified liquor leaves the effluent plant a continuous sample is taken and passed through a Pye flow type electrode assembly and a continuous recording of the final effluent pH value is taken before the effluent is passed into the drains.

The automatic pH control equipment employed on this plant was supplied and installed by W. G. Pye & Co. Ltd., Cambridge, to a rigid specification laid down by Texas chemical engineers.

Circle 364 for further information

OXYGEN ANALYSIS

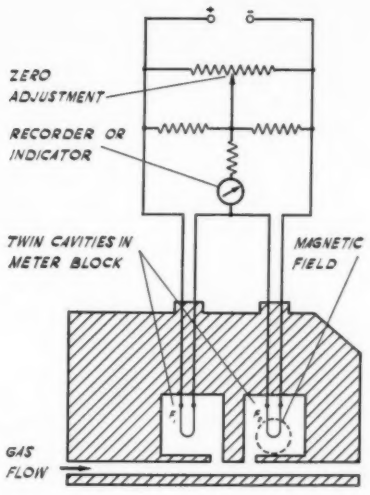
a new tool

The original Cambridge magnetic type oxygen analyser is now complemented by the filament type described below.

It is insensitive to CO_2 in the carrier gas and does not need to be level (an important advantage on board ship).

Whilst a major application will continue to be the measurement of excess air in furnace flues, many other industries will appreciate its qualities, which include high sensitivity and rapid response and, because of thermostatic control and pressure compensation, stable operating conditions.

It can be used with a galvanometric or electronic indicator and/or recorder.



The following is a brief description of the principle of operation:

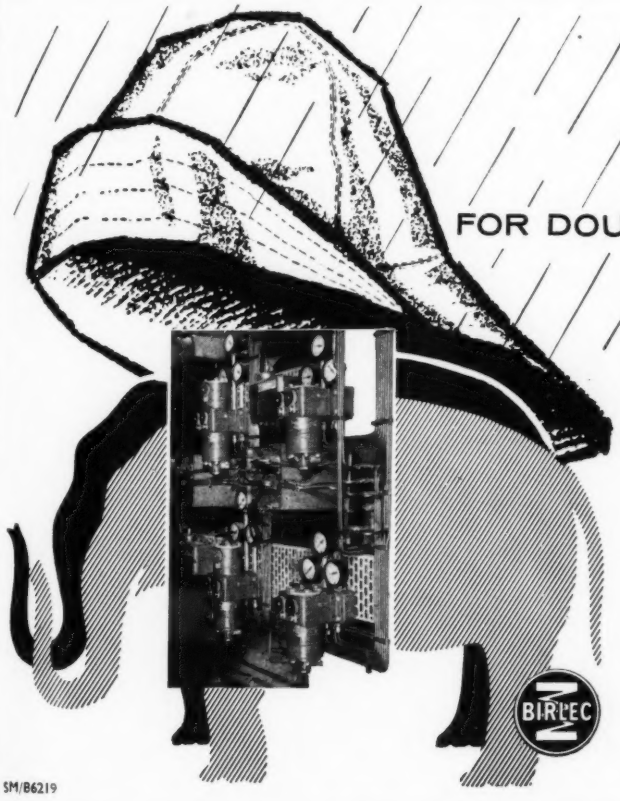
The two filaments are heated by an electric current and form two arms of a Wheatstone bridge.

A magnetic field is directed across the cell containing filament F_2 in such a way that it is partly within the heated zone created by the filament and partly outside it. When a sample gas containing oxygen passes through the instrument, the oxygen is attracted into the magnetic field, the attraction being greater at the cool edge of the field owing to the higher paramagnetic susceptibility of the cool oxygen. The consequent pressure difference across the field induces a flow of gas which cools filament F_2 altering its resistance in relation to F_1. This causes an unbalance of the bridge, the amount of which is measured by an indicator or recorder calibrated directly in oxygen percentage.

Write for new List 281Y. For future publications ask for Mailing Form Y/9/61

Cambridge **OXYGEN ANALYSERS** (Magnetic Types)

CAMBRIDGE INSTRUMENT COMPANY LTD., 13 GROSVENOR PLACE, LONDON, S.W.1 Tel: BELgravia 5066 Ext. 14



SM/B6219

DRY

FOR DOUBLE ELEPHANTS

Dry compressed air might well find an application in the Elephant House but, in this instance, we refer to the paper industry—in the application illustrated, the Reed Paper Group's Aylesford Paper Mills are using Electroflo Process Controllers operated by compressed air, dried by Birlec Air Drying Equipment.
Birlec Autosorbers are the new compact, inexpensive yet fully automatic Birlec moisture adsorbers for drying compressed air and other gases. They represent the concentration of 25 years' experience and development in a highly practical design.
They are available with test-proven performance ratings, in a range of types and sizes covering most regular needs. They bring new scope and security to air-operated controls and other pneumatic and process-gas systems.

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Circle 365 for further information

(*Continued from page* 1169)

Hewlett-Packard Catalogue

Short form catalogue, 1960-1961, from Hewlett-Packard gives details of the company's electronic test instruments. The range includes a complete coverage in quality oscilloscopes, d.c. to 1,000 Mc/s, frequency measuring and monitoring equipment, microwave impedance and power measuring equipment, single generators from 50 kc/s to 21 kMc/s and wide band amplifiers for fast circuit work. Illustrations of the various models together with brief specification details are also mentioned.

Circle **75** *for further details.*

Semiconductor News

The new Ediswan Mazda P.XC171 output transistor has been developed to provide a power in the speech coil of approximately 1 watt, combined with easy drive requirements, and has an unusually level d.c. β curve, which ensures low harmonic distortion up to the full rated power output. This is exemplified by the ability to obtain the above performance in production receivers up to an ambient temperature of 55°C with batteries of 9 or 12 volts, while employing the new Ediswan Mazda driver transistor P.XB113, at mean currents between 4 and 5 mA.

The LF6 package of three audio transistors consists of a P.XB113 driver stage transistor and P.XC171 matched pair of output transistors supplied in a holder which is designed to give a low thermal resistance when mounted on a heat sink. There are two tentative characteristic curves of Ediswan Mazda transistor Type XC171 and preliminary data for germanium p-n-p junction transistor Type P.XB113, together with details of typical circuits for audio amplifiers incorporating P.XC171 transistor.

Circle **76** *for further details.*

Touro-Strob

The Touro-Strob is an electro-optical tachometer with all the advantages of speed measurement without the necessity of connecting wires or mechanical coupling It is designed for the measurements of speeds between 200 and 15,000 rev/min in three ranges: 200-900 rev/min, 900-3,600 rev/min, and 3,600-16,000 rev/min. Details of the particular types of Touro-Strob with the necessary accessories are included together with a list of their various applications.

Circle **77** *for further details.*

Hilger Journal

The June issue of this journal produced by Hilger & Watts Ltd. has among its contents various articles of interest. These include "Electron Spin Resonance", "Nuclear Gamma-Ray Spectroscopy by Crystal Diffraction", and contained in the section entitled News and Notes is the fact that Hilger & Watts are providing a spectrochemical equipment service in Israel.

Circle **78** *for further details.*

Calculators

The latest literature from Broughtons of Bristol provides information on their range of calculating machines now available to the home market. The Mercedes range, of which there are three models, are the RSM 44, RSM 43 and R 40. The RSM 43 and 44 are capable of a wide range of functions, such as addition, subtraction, multiplication, division, advanced mathematical problems and repeated multiplications. Their especially large capacities of 20 columns on the keyboard, 20 figures in the product and complement register, 20 figures in the store register and 10 figures in the quotient or revolution register make it possible to set up both factors of multiplication or of division simultaneously.

The Triumphator Model KN hand operated type calculator has been designed in accordance with the requirements of small and medium size businesses, incorporating all the features which one may expect to find in an expedient and low priced compact calculator.

Circle **79** *for further details.*

Technical Writing Service

Pergamon Press announce the creation of a Technical Writing Division which will meet the need for an efficient and integrated technical writing and illustrating service, capable of undertaking the complete design and production (including rewriting and translation from and into foreign languages) of all types of technical and printed matter, instruction/training manuals, user/operator handbooks, sales brochures, catalogues and company reports.

Details of this new service are included in a leaflet entitled "Publishing with Pergamon Press Guarantees You . . . ".

Circle **80** *for further details.*

Wire Stripper

The advantages of the new stripping tool, Model W.S./S/IP. for plastic covered wires are the ease and speed of use by untrained operators without danger of damage to the conductors. These advantages, together with special features, are shown in the latest leaflet issued by Lyteze Products Ltd.

Circle **81** *for further details.*

Cables

A folder containing information concerned with electric wiring for lighting and power is available from Pyrotenax Ltd., dealing with the company's mineral insulated copper covered cables.

There is also a 20 page handbook which has been prepared to assist with the installation and sealing instructions.

Circle **82** *for further details.*

Catalogue Supplement

The Belling & Lee Ltd. supplement to the 1959-60 edition of their general catalogue has been produced to bring holders of the catalogue up to date with information concerning their components pending the publication of a complete new edition to be published next year. On the back cover there is a list of items classed as obsolescent.

Circle **83** *for further details.*

Pyrotenax Ltd.

To commemorate their Silver Jubilee, Pyrotenax Ltd. have issued a glossy brochure giving details of the company's expansion over the last quarter of a century. In particular mention is made of the pre-war introduction of a cable which could neither cause nor contribute to fire and which could successfully operate in conditions of high temperature. After the war there was an increasing demand for the standard cable and for the new products which were introduced to meet the requirements of the housing programme and the development of a range of heating cables assisted in maintaining and improving the company's growing reputation.

There are various sections devoted to manufacture, testing, characteristics and applications of the cables.

Circle **84** *for further details.*

Scanner

The many applications of Decca Radar are described in the summer edition of their house journal. Among those included are windfinding, defence, weather, airfield control, marine, and harbour radar.

There is a chapter on Decca Radar's world service and the publication is well illustrated.

Circle **85** *for further details.*

Indicating Pneumatic Temperature Controller

The indicating pneumatic temperature controller from Cambridge Instrument Co. Ltd. described in the new List 103 is an instrument for controlling the working temperatures of vats, autoclaves, or other similar containers; and the temperatures of refrigerating, air-conditioning, or other similar plants and processes, between −20 and + 340°C (−10 and + 650°F).

When the temperature of the container or process rises or falls beyond a predetermined level, the controller automatically cuts off the piped supplies of heating or cooling fluid or gas until the temperature returns to the pre-set level. The controlled temperature can either be that of the process or container itself or, less frequently, that of the piped supplies.

The instrument can be used in almost any industrial process where the flow of heating or cooling medium can be regulated by a diaphragm valve.

Circle **86** *for further details.*

Stock Control Aids

Stockmarkers and self-adhesive label holders are the subject of a four-page leaflet available from KABI (Electrical & Plastics) Ltd.

Circle **87** *for further details.*

Turbidity Indicator

The Radiovisor turbidity indicator and alarm is intended for monitoring a liquid flowing through a pipe, giving immediate warning should it run turbid or cloudy.

Its applications, together with mechanical and specification details, are given in Ref. F561/T from Radiovisor Parent Ltd.

Circle **88** *for further details.*

Circle **366** for further information

TELCON METALS LIMITED

precision resistance and thermo-couple wire

TELCONSTAN is a high purity nickel and copper alloy of very low temperature co-efficient of resistance.

TELCONSTAN has a virtually constant ohmic resistance over the working temperature range (20°C to 100°C) of electrical instruments and apparatus. It also has good mechanical properties and resistance to corrosion. By reason of these physical characteristics, it is an excellent alloy, in wire or tape form, for shunts, instrument, relay and control resistors and in foil form for printed circuits.

THERMOCOUPLE TELCONSTAN is available for thermocouples and compensating cables. TELCONSTAN versus high conductivity copper can be used for the measurement of temperatures up to 350°C; with pure iron instead of copper, the range is extended to 800°C.

The following table indicates the figures normally obtained with Thermocouple Telconstan versus High Conductivity Copper, but individual requirements are supplied as required:—

Temp. °C.	Millivolts.
0	0.00
50	2.02
150	6.66
200	9.20
250	11.9
300	14.7
327	16.2
350	17.6

Cold Junction 0°C.

THERMOCOUPLE TELCONSTAN Wire is supplied in the annealed condition in all gauges.

The principal properties of TELCONSTAN are:—

Specific resistance . . 48 microhm cm.
Temperature coefficient of resistivity . . . . . 0.000014/°C from 20-100°C
Tensile strength (annealed) . . . . . 27 tons in – ³
Melting point . . . . . 1250°C
Specific gravity 8.9
Coefficient of thermal expansion 0.000014/°C from 20-100°C
Thermal conductivity 0.22 watt/cm/°C

TELCONSTAN FOIL For Printed Circuits, Strain Gauges and other applications.

Thickness	Width	Weight in lbs. per 100 ft.
.001″	6″	2.30
.0008″	6″	1.84
.0006″	6″	1.38

Standard tolerance ± 10% on thickness.

TELCONSTAN RESISTANCE WIRE IS SUPPLIED IN SWG SIZES 3 to 47

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If you're all tied up—call us in to assist.

We also supply tubes in copper, brass and precision tubular parts in non-ferrous metals to your specification.

ELLAY TUBES LIMITED
COX GREEN WORKS · MAIDENHEAD · BERKS · TEL.: MAIDENHEAD 3303

Circle **367** for further information

Sales & Service Overseas

Negretti & Zambra Ltd. have recently issued a revised and up-to-date version of their publication S109 which lists and describes the company's sales and service overseas.

There is a section under the collective heading of directory which includes—classification of products, postal and telegraphic address and telephone number.

Circle **89** *for further details.*

Marking Equipment

A leaflet from Electromark (G.B.) Ltd. outlines the company's system of marking metals.

Three types of mark can be made on most metals by variation of the controls, these are: a.c. a dark mark by utilising the cyclic variation of the current; d.c. etch, a white mark; and d.c. plate, with polarity reversed, a dark plated mark.

Circle **90** *for further details.*

Loughborough "Review"

The July issue of *Review*, which is the second in the series of two-monthly bulletins of new products for the laboratory and other items of interest is published by the Loughborough Glass Co. Ltd. Various types of Gelman air-sampling equipment are mentioned including sequential, hurricane air, bantam air, battery air and paper tape air.

Circle **91** *for further details.*

Mini-Mounts

Vulcascot (Great Britain) Ltd. have recently issued a leaflet introducing their newly developed Mini-Mount designed for small workshop machines, accountancy and other office machines. This is the latest addition to the Vulcascot range of vibration damping rubber mounts.

Circle **92** *for further details.*

"Platinum Metals Review"

The July, 1961, issue of *Platinum Metals Review* from Johnson, Matthey & Co. Ltd., a quarterly survey of research on the platinum metals and of developments in their applications in industry, includes several articles of interest, namely: Platinum Alloy Permanent Magnets; The Platinum Metals in Temperature Measurement; Iridium-Platinum Wire for Diodes; and High Temperature X-ray Diffraction.

Circle **93** *for further details.*

Honeywell Revised Flow Handbook

The third edition of the Flow Meter Engineering Handbook has recently been completed by the American Honeywell organisation. The new edition has 170 pages and deals with steam, liquid and gas flow calculation, each with all data necessary to calculate or check an orifice plate installation. There are also schematic diagrams, graphs, charts and tables. Three solutions to a flow problem are outiined in each chapter; an approximation check, a nominal orifice bore calculation and a precise orifice bore calculation.

The book is available through Honeywell Controls Ltd. Price £2 15s.

Circle **94** *for further details.*

"General Radio Experimenter"

The May issue of this publication contains an article devoted to the Type 1130-A digital time and frequency meter, a frequency counter using new circuits and having a high degree of reliability.

Specifications are included.

Circle **95** *for further details.*

"Hilger & Watts News"

Included in the June issue of *Hilger & Watts News* are articles on carburising and heat treatment and the Microspin (the electron spin resonance apparatus).

Circle **96** *for further details.*

Muirhead "Technique"

The July issue of *Technique*, a journal of instrument engineering, from Muirhead & Co. Ltd., contains the following articles: "Synchro following accuracy", by J. G. Dixon; "The D-846-A transistorised servo amplifier and some unusual applications", by R. F. Griffin; "The D-990 weather chart transmitter", by F. J. Hunter.

Circle **97** *for further details.*

Dawe Digest

The June issue of this publication, which is the quarterly technical bulletin of Dawe Instruments Ltd., includes, among others, an article on the application of ultrasonics to electroplating processes.

Circle **98** *for further details.*

Durestos

Durestos is a moulding material manufactured from intimate blends of asbestos and thermosetting resins and is available in three forms—felt, flock and powder. This material is the subject of a booklet SA. 6 entitled *Resinated Asbestos Moulding Materials* from Turner Brothers Asbestos Co. Ltd. Descriptions of its uses for high-pressure, low-pressure, and no-pressure moulding techniques, together with details on machining moulded components, are included. Technical data covering strengths, chemical resistance, thermal conductivity and density are given and the booklet is well illustrated.

Circle **99** *for further details.*

High-speed Three-colour Pyrometer

A three-colour pyrometer, capable of making 1,000 temperature determinations every second, has been developed by the National Bureau of Standards. This device, which eliminates many of the limitations of one- and two-colour pyrometers, will be especially useful in the measurement of rapidly changing temperatures.

THE principle of a high-speed three-colour pyrometer has been demonstrated by a prototype instrument developed by G. A. Hornbeck, of the National Bureau of Standards. The prototype is capable of making 1,000 individual temperature determinations per second in the temperature range 1,000 to 3,000°C with an uncertainty of about 1%. The high-speed characteristics of this pyrometer will be of value in the measurement of temperatures of limited duration. Potential applications include the measurement of the temperature of missile components during firing tests, of ablating nose-cone materials, and with modifications, of exploding wires.

In essence, this instrument forms a spectrum of the radiation from the source, masks out all but the three required wavelengths, and presents these wavelengths to the detector sequentially. When operating at high speed, it is necessary to record the data with an oscilloscope, magnetic tape, or other high-speed recorder.

Certain limitations inherent in one- and two-colour pyrometers have been eliminated in this instrument. Brightness temperatures measured with one-colour pyrometers can be converted to true temperatures only if the spectral emissivities of the materials being observed are known. To avoid dependence upon knowledge of absolute values of emissivity, two-colour or ratio pyrometers have been used in a number of applications. A limitation is once again encountered: the emissivities at the two wavelengths must be identical. Unfortunately, this is not always the case. True temperatures can be obtained through the use of three-colour pyrometry, provided the emissivities are a linear function of the wavelengths selected. This criterion is generally true in the near-infra-red region of the spectrum. Therefore, this instrument was developed to determine temperatures by measuring the intensities at three different wavelengths.

A unique system for the separation and measurement of three discrete wavelengths was incorporated in this instrument. Radiation from the source of interest passes through an entrance slit and is rendered parallel by a collimating mirror. The beam then passes through a prism and the resulting spectrum is brought in focus with a second mirror. The major feature of this optical system is a right-angle mirror placed in the vertical plane of the spectral image. As a result of reflection from this mirror, the image is displaced vertically, and retraces its path through the optical system. A mirror placed near the entrance slit reflects the beam to a radiation detector. A mask to pass the selected wavelengths is placed in the path of the beam coming from the right-angle mirror, and a rotating slotted chopper is used to produce a sequential exposure to the detector tube. Because the sensitivity of most fast radiation detectors is wavelength dependent, adjustable attenuating pins are placed in the band pass for each wavelength and set so as to pass the correct amount of radiation at the time of calibration.

At present, considerable inconvenience is experienced in the mechanical adjustments necessary to change to different wavelengths. However, provision is being made to set the desired wavelengths by dial. A suggested set of wavelengths which would give acceptable sensitivity and avoid atmospheric absorption in the infra-red was calculated to be 1·1, 1·6, and 2·1μ.

Circle 368 for further information

EKCO

X-Y Recorder

Type E193

Ekco Type E193 is a high-speed X-Y Recorder which plots the relationship between two inter-dependent variables directly on to standard 10″ x 7½″ graph paper.

The wide sensitivity range (1 mV. per 1″ to 50 V. per 1″) and exceptionally fast response (full-scale travel in 200 milliseconds) make it unusually versatile in the fields of performance investigation and process control.

This instrument will find wide use in research laboratories, industrial organisations and hospitals or in any field in which it is necessary to chart rapidly-changing parameters accurately.

EKCO ELECTRONICS

Ekco Electronics Ltd., Southend-on-Sea, Essex, England. Tel: Southend 49491

WPS-306

Circle 369 for further information

SIMPLIFIX

NYLON TUBE COUPLINGS

Simple! Secure! Speedy!

Simplifix Nylon Tube fittings are dependable, practical and economical. They are easily and quickly fitted. No work is needed on the end of the tube because the specially designed brass olive ensures a perfect seal and prevents the tube twisting when the joint is made. The coupling bodies are the same as those used for copper tube. Olives and securing nuts can be supplied separately. Only one stock of bodies is needed to make up fittings for Copper or Nylon Tube. Simplifix Nylon Tube couplings, olives and securing nuts are available for O.D. tube sizes of $\frac{3}{16}$″, $\frac{1}{4}$″, $\frac{5}{16}$″, $\frac{3}{8}$″ and $\frac{1}{2}$″. Nylon Tube for these couplings can be supplied in a wide range of colours.

The comprehensive Simplifix catalogue will gladly be forwarded on request, and our Technical Advisory Service is always available.

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FORTHCOMING EVENTS

Sept. 4th–9th. **Flying Display and Exhibition.** Flying Ground, Farnborough. (Society of British Aircraft Constructors Ltd., 29, King Street, St. James's, London, S.W.1.)

Sept. 5th–15th. **International Packaging Exhibition.** Olympia, London. (Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3.)

Sept. 10th–24th. **3rd International Trade Fair.** Brno, Czechoslovakia.

Sept. 11th–15th. **International Instrument Automation Conference and Exhibition.** Los Angeles, California. (Lep Transport Ltd., Sunlight Wharf, Upper Thames Street, London, E.C.4.)

Sept. 12th–14th. **Griffin & George Exhibition.** Welsh College of Advanced Technology, Cathays Park, Cardiff.

Sept. 14th–25th. **Salon National de Radio et Television.** Paris. (S.D.S.A., 23, Rue de Lubeck, Paris 16.)

Sept. 18th–21st. **Griffin & George Exhibition.** Chorlton Town Hall, Cavendish Street, Manchester.

Sept. 23rd–Oct. 5th. **International Technical Exhibition.** Turin, Italy. (Dr. G. Boella, Fiat England Ltd., Water Road, Wembley, Middlesex).

Sept. 26th–Oct. 6th. **The First International Heating, Ventilating and Air Conditioning Exhibition.** Olympia, London. (During Exhibition: **Conference on Heating, Ventilating and Air Conditioning**—Sept. 27th–Oct. 4th.) (Industrial Exhibitions Ltd., 9, Argyll Street, London, W.1.)

Oct. 2nd–11th. **49th National Business Efficiency Exhibition.** Olympia, London. (O.A. & B.E. Trades Association, 64, Cannon Street, London, E.C.4.)

Oct. 3rd–12th. **Electronic Computer Exhibition.** Olympia, London. (Mrs. Elliott, M.B.E., 64, Cannon Street, London, E.C.4.)

Oct. 4th–11th. **Royal Netherlands Industries Fair.** Utrecht, Holland.

Oct. 9th–11th. **National Electronics Exhibition.** Chicago, U.S.A. (National Electronics Conference Inc., 228, North La Salle Street, Chicago 1).

Oct. 9th–13th. **4th British Components Show.** R.E.C.M.F. Marmorhallar, Stockholm.

Oct. 13th–22nd. **International Mechanical Handling Exhibition.** Paris, France. (Salon de la Manutention, 40, Rue du Colisée, Paris, 8.)

Oct. 17th–19th. **Engineering Industries Association Engineering Display.** New Horticultural Hall, London. (Engineering Industries Association, 9, Seymour Street, London, W.1.)

Oct. 17th–26th. **Industrial Equipment Exhibition.** City Hall, Manchester. (Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3.)

Oct. 18th–28th. **International Motor Exhibition.** Earls Court, London. (A.A. Goode, Society of Motor Manufs. & Traders Ltd., Forbes House, Halkin Street, London, S.W.1.)

Oct. 21st–29th. **International Electronics Exhibition.** Ljubljana, Yugoslavia. (Gospodarsko Razstavisce, Titova Street c. 50, Ljubljana).

Oct. 25th–26th. **Computer Applications Symposium,** Armour Research Foundation, Morrison Hotel, Chicago, Illinois.

Oct. 31st–Nov. 3rd. **2nd Effluent and Water Treatment Exhibition and Convention.** Seymour Hall, London, W.1. (Thunderbird Enterprises Ltd., 140, Cromwell Road, London, S.W.7.)

Nov. 7th–12th. **6th Congress and Exhibition.** Automation and Instrumentation, Milan, Via del Politecnico, 10. ("Automazione e Strumentazione", Via Marcona 15, Milano).

Nov. 8th–10th. **Conference on Non-destructive Testing in Electrical Engineering.** London. (Secretary, I.E.E., Savoy Place, London, W.C.2.)

Nov. 13th–16th. **Meters, Gauges and Measuring Instruments Exhibition.** Old Horticultural Hall, London. (Metro Trade (Exhibitions) Ltd., 67-9, Chancery Lane, London, W.C.2.)

Nov. 13th–18th. **Engineering Materials and Design Exhibition and Conference.** Earls Court, London. (Industrial & Trade Fairs Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1.)

Nov. 13th–18th. **International Factory Equipment Exhibition.** Earls Court, London. (Industrial & Trade Fairs Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1.)

Nov. 14th–Jan. 1st., 1962. **Indian Industries Fair.** New Delhi.

Nov. 27th–30th. **4th Corrosion and Metal Finishing Exhibition.** Olympia.

Jan. 15th–19th, 1962. **Physical Society Exhibition of Scientific Instruments and Apparatus.** Old and New Horticultural Halls, London. (The Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7.)

Feb. 16th–20th, 1962. **International Radio and Electronic Components Exhibition.** Paris, France. (Federation Nationale des Industrie Electroniques, 23, rue de Lubeck, Paris, 16.)

March 20th–24th, 1962. **Electrical Engineers (A.S.E.E.) Exhibition.** Earls Court, London. (Electrical Engineers (A.S.E.E.) Exhibitions Ltd., 6, Museum House, 25, Museum Street, London, W.C.1.)

March 26th–29th, 1962. **I.E.R. International Convention.** New York. (Institute of Radio Engineers, 1, East 79th Street, New York 21.)

April 9th–13th, 1962. **International Pipes, Pipelines, Pumps and Valves Exhibition and Conference.** Earls Court, London. (Scientific Surveys Ltd., 97, Old Brompton Road, London, S.W.7.)

April 30th–May 4th, 1962. **International Compressed Air and Hydraulics Exhibition and Conference.** Olympia, London. (Commercial Exhibitions Ltd., St. Richards House, Eversholt Street, London, N.W.1.)

May 8th–18th, 1962. **Mechanical Handling Exhibition.** Earls Court, London. (Iliffe Exhibitions Ltd., Dorset House, Stamford Street, London, S.E.1.)

May 18th–June 3rd, 1962. **British Trade Fair.** Stockholm.

May 28th–June 2nd, 1962. **Instruments, Electronics and Automation International Exhibition.** Olympia, London. (Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1.)

June 20th–30th, 1962. **2nd Chemical & Petroleum Engineering Exhibition.** Olympia. (Engineering in Britain 34, Victoria Street, London, S.W.1.)

June 25th–28th, 1962. **4th Congress of the Federation of European Petroleum Equipment Manufacturers.** Church Hall, Westminster. (Engineering in Britain, 34, Victoria Street, London, S.W.1.)

July 23rd–28th, 1962. **Engineering Exhibition.** Sydney, Australia. (Industrial Public Relations Services of Australia, Box 4962, G.P.O. Sydney, N.S.W.)

Sept. 3rd–8th, 1962. **1st International Congress on Chemical Machinery, Chemical Engineering and Automation.** Brno, Czechoslovakia. (Organising Committee for the 1st International Congress on Chemical Engineering and Automation, Výstaviště 1, Brno, Czechoslovakia).

Oct. 15th–18th, 1962. **Materials Handling Exhibition.** Toronto, Canada. (Materials Handling in Canadian Industry, 481 University Avenue, Toronto).

Oct. 15th–19th, 1962. **Instrument-Automation Conference and Exhibition.** New York, U.S.A. (Instrument Society of America, 313, Sixth Avenue, Pittsburgh 22, Pa.)

Oct. 15th–20th, 1962. **Laboratory, Measurement and Automation Techniques in Chemistry Exhibition.** Basle, Switzerland. (Sekretariat, Schweizer Mustermesse, Basle, 21).

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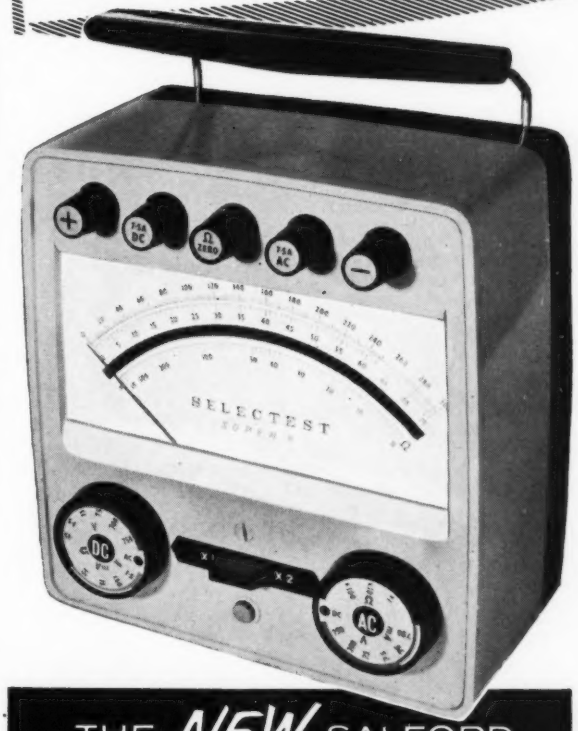

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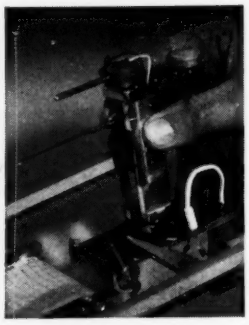

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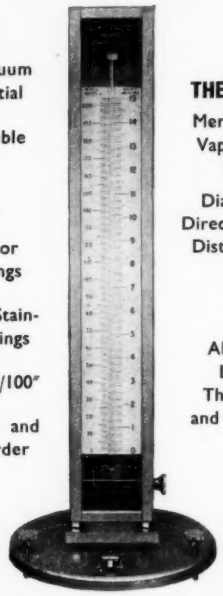

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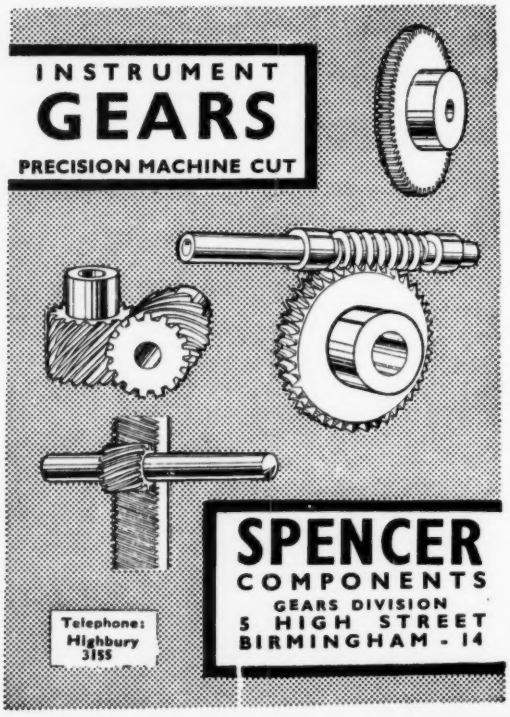

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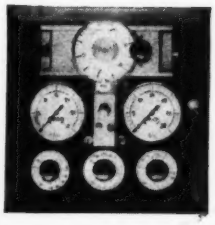

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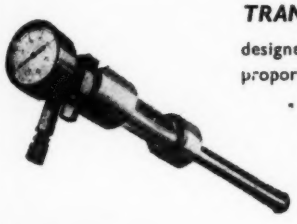

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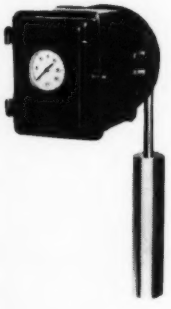

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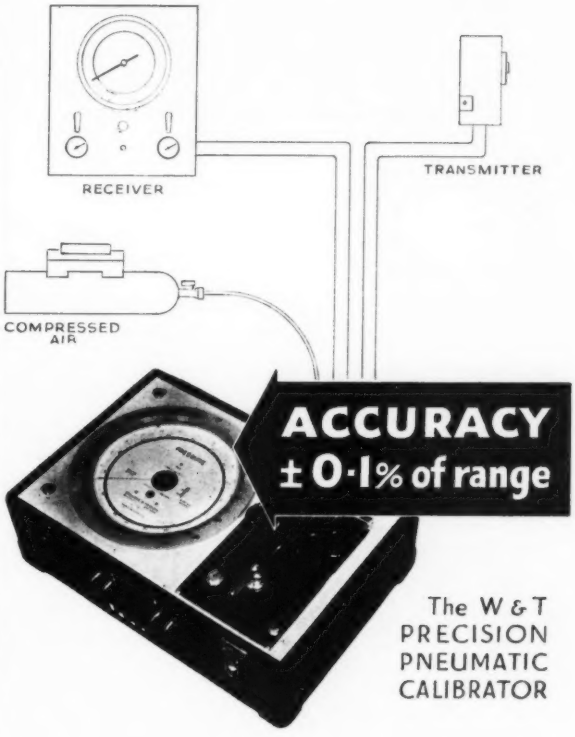

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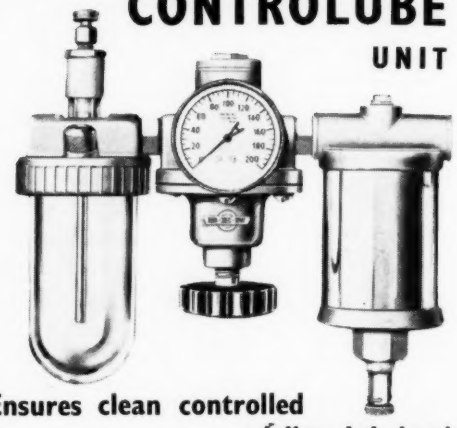

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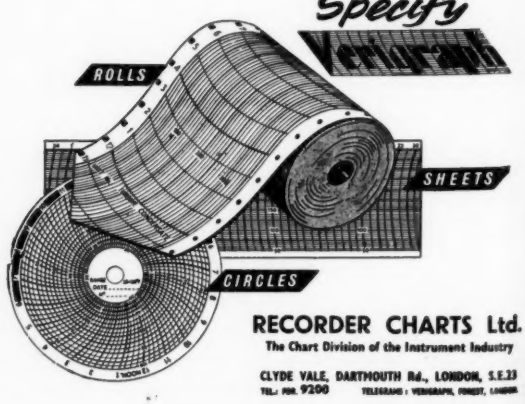

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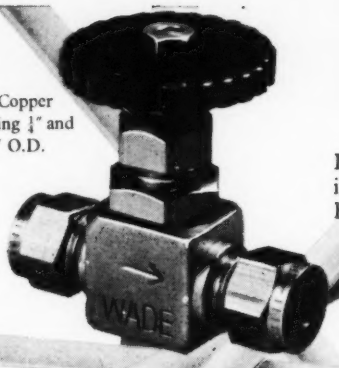

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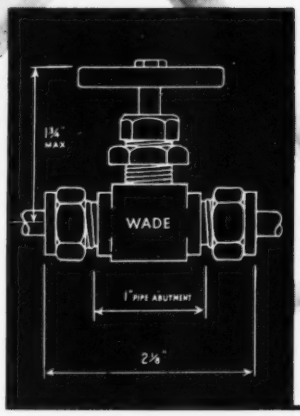

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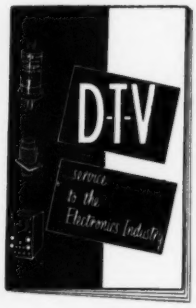

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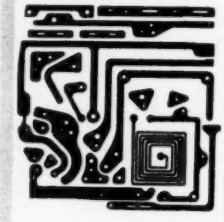

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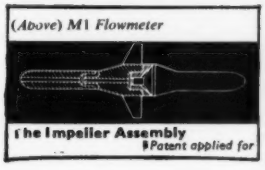

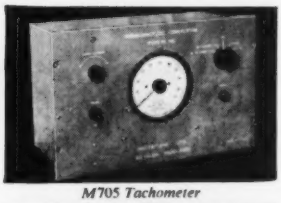

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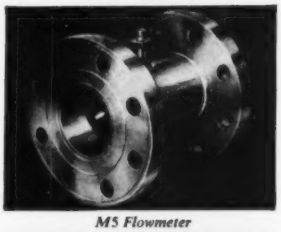

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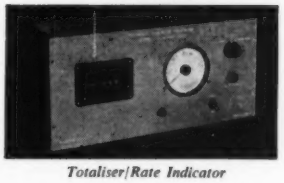

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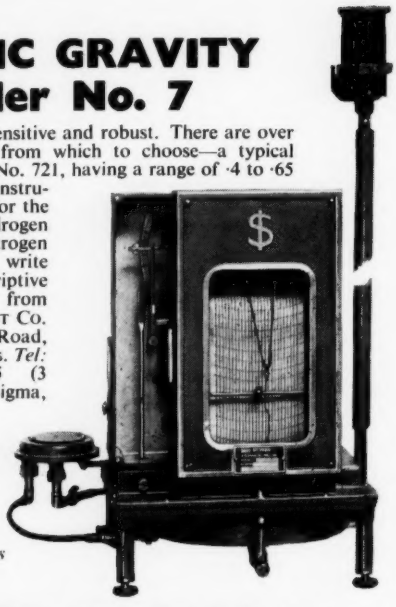

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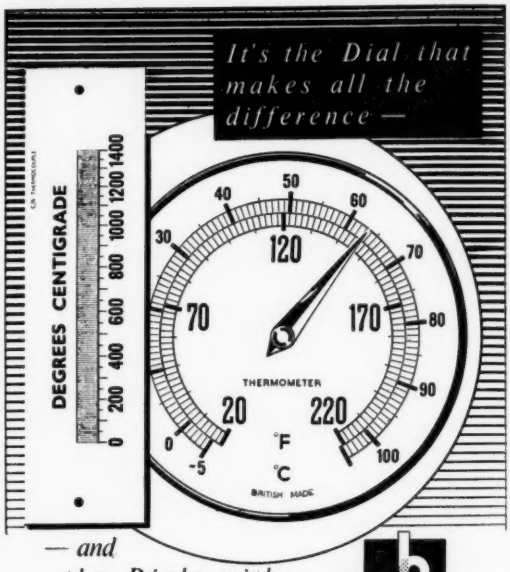

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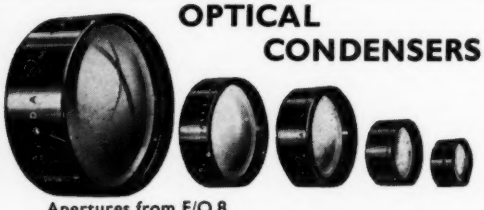

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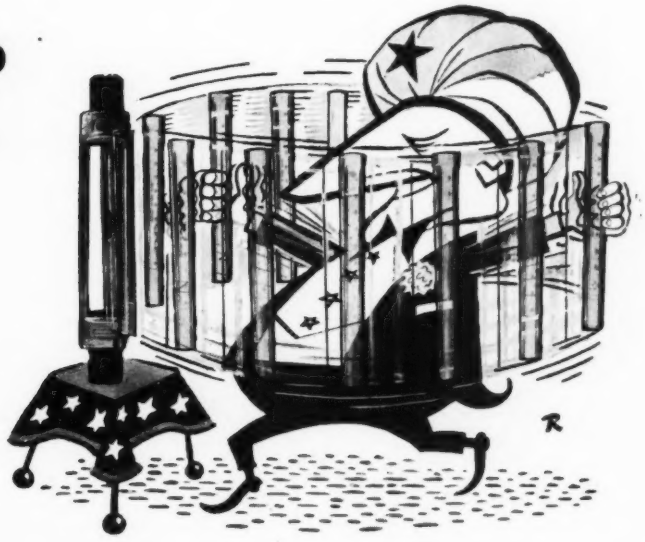

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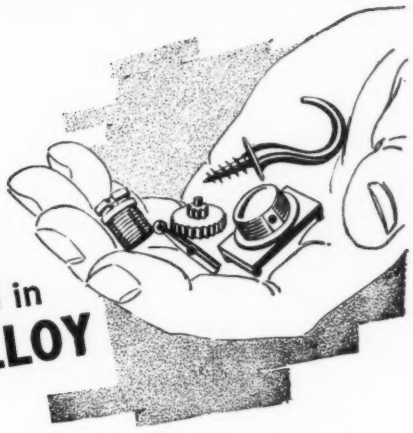

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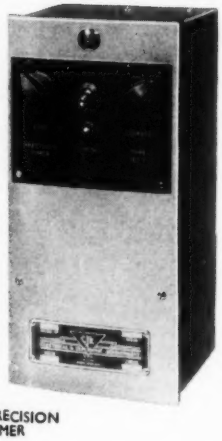

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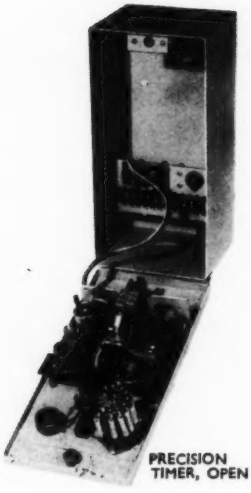

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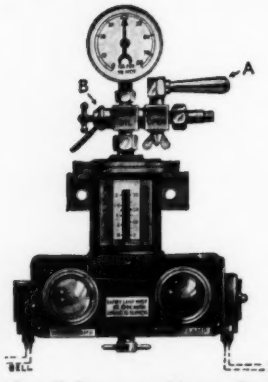

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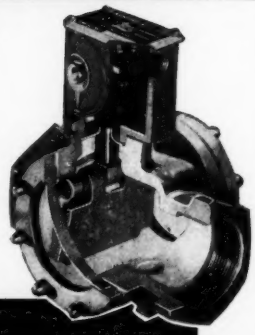

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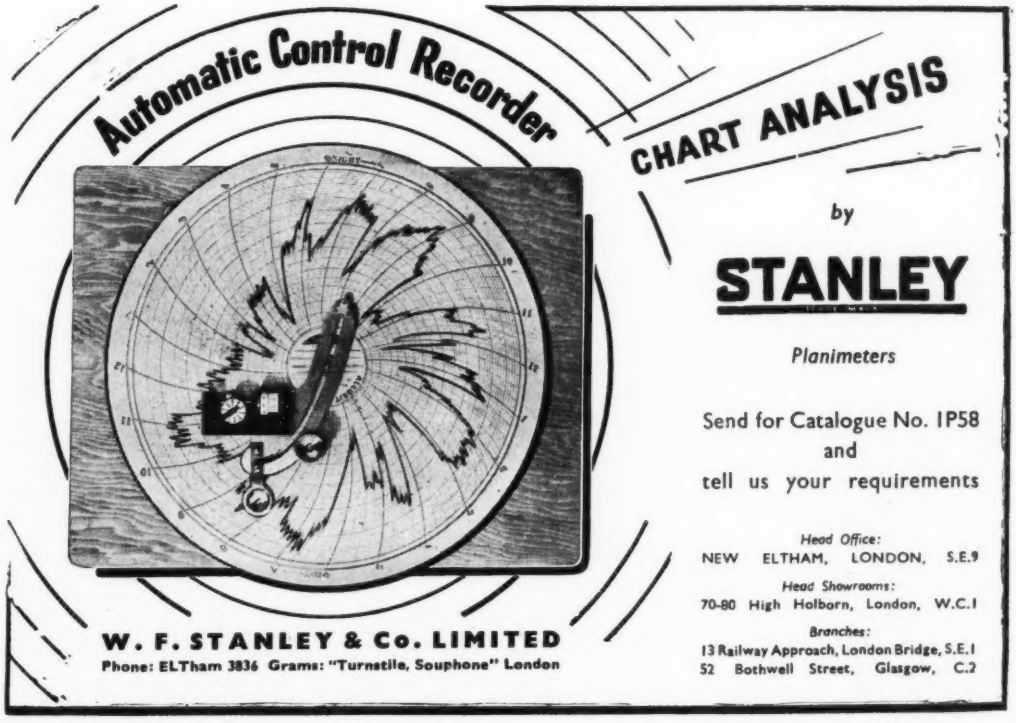
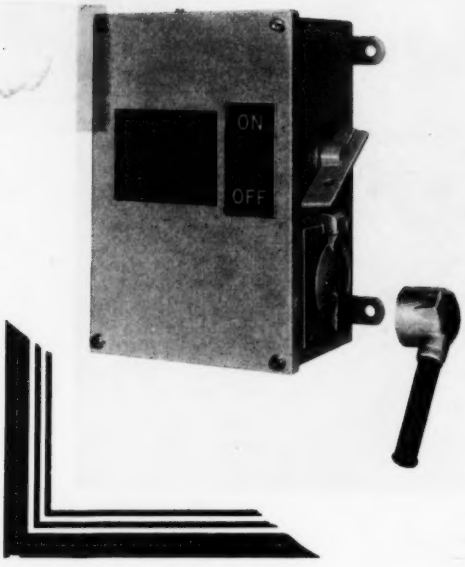


Circle 402 for further information

Circle 403 for further information

SAFETY FOR
Electric-Tool operators—
a unit with a guarantee of overall efficiency



This small and extremely reliable safety unit protects operators of electrical tools which may break down to EARTH or develop some form of insulation fault.

The Switch ensures immediate isolation of any portable electric tool fed from it.

The unit automatically tests the earth connections before the tools to which it is supplying current are energised—which test is continuant so long as the tools are in use.

The standard unit is available for normal single or three phase A.C. supply voltages with ratings up to 60 amps. and if fitted with contactors this type of unit can be used on circuits in excess of 60 amperes.

For full details of Automatic Earth Proving Switches

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